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ORIGINAL ARTICLES.

I.—On a Collection of Jurassic Cephalopoda from Western Australia—Obtained by Harry Page Woodward, F.G.S., Government Geologist—with Descriptions of the Species.

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(PLATE XII.)

THE Collection of Western Australian Cephalopoda which has been handed to me for examination consists of twelve specimens, viz. two Belemnites, one Nautilus, and nine Ammonites. One Ammonite was obtained from Cape Riche, E. of Albany; all the other specimens were collected near Champion Bay. They are chiefly internal casts, and on the whole are badly preserved: the Nautilus is in a fair state of preservation; but the Ammonites are very imperfect; the suture-line can be satisfactorily made out in only one specimen, hence the generic determinations must be regarded as only approximate. There may be some difference of opinion as to the desirability of founding species upon such poorly preserved fossils, but as several distinct forms can be made out, it seems desirable to assign names to them for convenience of reference, and it is hoped that the figures which supplement the descriptions will enable the species to be easily recognised.

The British Museum (Natural History) Collection contains two Ammonites (Nos. C. 4708 and C. 4709) from "the Greenough, Champion Bay, Australia," which were presented by Captain Elliot to the Museum of Practical Geology, Jermyn Street, and subsequently transferred from that Museum to the National Collection.

I desire to express my thanks to Dr. Henry Woodward, F.R.S., for valuable suggestions; and to the Rev. H. H. Winwood, M.A., F.G.S., for the loan of the Western Australian Cephalopoda which were figured and described by the late Mr. Chas. Moore, now in the Bath Museum. My thanks are also due to Mr. W. Rupert Jones for directing my attention to some Western Australian fossils which are preserved in the Museum of the Geological Society of London.

BELEMNOIDEA.

Belemnites (Agricola), Lister.

Belemnites, sp.

The collection contains only two fragments referable to this genus. The one is 42 mm. in length, much abraded, and partly obscured by matrix. The fragment appears to have been originally nearly cylindrical, but its dorsal surface has been considerably abraded, whilst its ventral surface and portions of the sides are obscured by matrix. A little below the middle of the specimen, its dorso-ventral diameter is 13·5 mm. and its transverse diameter 14·0 mm. One end is obliquely abraded and shows the presence of a ventral groove, from which a fissure passes inwards to the apical line, which is here nearer the ventral than the dorsal surface. The extent of the groove cannot be seen, as the ventral surface is obscured by matrix.

The other fragment is 15·5 mm. long and is divided longitudinally so as to present a median section; at the larger end the dorso-ventral diameter is 8·5 mm., its transverse about 8·0 mm., whilst at the smaller end the dorso-ventral diameter is 6·5 mm. and the transverse about 8·0 mm.

These fragments are probably referable to the species which Clarke[1] and Moore[2] identified from W. Australia as *Belemnites canaliculatus*, Schlotheim.[3] Moore's figured specimen is in the Bath Museum.

Locality.—Champion Bay, Western Australia.

NAUTILOIDEA.

Nautilus, Breynius.

Several Mesozoic Nautili have been recorded from Australia, viz. *Nautilus sinuatus*?, J. Sowerby,[4] *Nautilus semistriatus*, d'Orbigny,[5] and a probably new species[6]—all from Western Australia; and *Nautilus Hendersoni*, R. Etheridge, *fil.*,[7] from Queensland.

The present collection contains only one specimen of *Nautilus*; this appears to belong to a new species, and is here described as *N. perornatus*.

Nautilus perornatus, sp. nov. (Pl. XII. Figs. 1*a*, *b*, *c*.)

1870. *Nautilus semistriatus*, C. Moore, "Australian Mesozoic Geology and Palæontology," Quart. Journ. Geol. Soc. vol. xxvi. pp. 230–232. (Not of d'Orbigny.)

Sp. char.—Shell moderately inflated, rapidly enlarging; greatest thickness near the umbilical margin; sides somewhat flattened, sloping towards the periphery;

[1] Quart. Journ. Geol. Soc. vol. xxiii. (1867), p. 9.
[2] *Ibid.* vol. xxvi. (1870), pp. 227, 230, and 232, pl. xvi. fig. 7.
[3] Petrefactenkunde, 1820, p. 49.
[4] J. Sowerby, Min. Con. vol. ii. p. 213, pl. cxciv. 1818; W. B. Clarke, Quart. Journ. Geol. Soc. vol. xxiii. (1867), p. 8.
[5] A. d'Orbigny, Pal. Franç. Terr. Jur. vol. i. 1842, p. 149, pl. xxvi.; C. Moore, Quart. Journ. Geol. Soc. vol. xxvi. (1870), pp. 230–232.
[6] W. B. Clarke, Quart. Journ. Geol. Soc. vol. xxiii. (1867), p. 9.
[7] R. Etheridge, *fil.*, in Jack and Etheridge, Geology and Palæontology of Queensland and New Guinea, 1892, p. 502.

periphery broad, flattened, its width about one-half that of the lateral area, its margins subangular. Umbilicus of moderate size, deep, with steep sides, exposing a portion of the inner whorls; margin rounded. Siphuncle not seen. Chambers rather deep, about two-fifths of the corresponding height (breadth) of the whorl in depth at the periphery; suture-line forming a sigmoidal curve on the side, its direction on the periphery not seen. Test covered with numerous subregular longitudinal ridges, about one-twelfth of an inch apart where the height of the whorl is three inches, and one-tenth of an inch apart where the whorl reaches five inches in height; between each pair of ridges lie five or six very fine thread-like wavy longitudinal lines.

Dimensions:—

Diameter of shell	$8\frac{1}{2}$ inches	(216	mm.)
Height of outer whorl	5 ,,	(127	,,)
Height of outer whorl above preceding whorl	about $3\frac{1}{2}$,,	(89	,,)
Thickness of outer whorl	about $4\frac{1}{2}$,,	(114·5	,,)
Width of umbilicus	$\frac{3}{4}$,,	(19	,,)
Depth of chamber at periphery where whorl has a height of $4\frac{1}{2}$ inches	$1\frac{5}{8}$,,	(41·5	,,)

Remarks.—This species is represented by only one example, which consists of the septate portion of the shell and the base of the body-chamber. One side is much abraded, but the periphery and the other side are well preserved, portions of the shell remaining on the umbilical and peripheral regions and on parts of the lateral area, sufficient to show that the ornamentation of the test extended over the whole of the sides; the greater part of the lateral area is denuded of the test, and shows the course of the suture-lines. The position of the siphuncle is not seen.

The collection of Western Australian fossils in the Bath Museum contains a *Nautilus*, which, though much worn, has a small fragment of the test preserved near the extremity of the shell and close to the periphery (hence probably assigned by Moore to *N. semistriatus*, d'Orb.), that enables the writer to identify it with the present species. The dimensions of the specimen are as follows:—

Diameter of shell	120 mm.
Height of outer whorl	77 ,,
Height of outer whorl above preceding whorl	51 ,,
Thickness of outer whorl (shell crushed on one side)	about 68 ,,
Width of umbilicus (obscured by matrix)	about 14 ,,
Depth of chamber where shell has a diameter of 95 mm.	21 ,,

This specimen does not show the position of the siphuncle.

Affinities and differences.—The species of Mesozoic Nautili which have hitherto been identified from Australia are *Nautilus sinuatus*?[1] and *Nautilus semistriatus*,[2] both from Western Australia. *Nautilus subsinuatus*, d'Orbigny[3] (=*Nautilus sinuatus*, J. Sowerby[4]) is distinguished from the present species by its more compressed form and the narrower and deeper lateral sinus of its suture-line. In *Nautilus semistriatus*, d'Orbigny,[5] the longitudinal ornaments do not

[1] W. B. Clarke, "On Marine Fossiliferous Secondary Formations in Australia," Quart. Journ. Geol. Soc. vol. xxiii. (1867), p. 8.

[2] C. Moore, "Australian Mesozoic Geology and Palæontology," *ibid.* vol. xxvi. (1870), pp. 230–232.

[3] Prod. de Paléont. Stratigr. vol. i. (1850), p. 260.

[4] Min. Con. vol. ii. p. 213, pl. cxciv. 1818. This name was preoccupied by Fichtel and Moll in 1803, and hence altered by d'Orbigny to *subsinuatus*.

[5] Pal. Franç. Terr. Jur. vol. i. 1842, p. 149, pl. xxvi.

cover the entire surface of the test as in the Australian species, but are confined to the peripheral and umbilical regions. The present species is closely allied to *Nautilus ornatus*, Foord and G. C. Crick,[1] from the Inferior Oolite of Sherborne and Dundry, but it is at once distinguished by the character of its ornaments. From *Nautilus intermedius*, J. Sowerby,[2] and *N. striatus*, J. Sowerby,[3] the Australian form is distinguished by the ornamentation of the shell; it is also less inflated than *N. striatus*. The sculpture of the present species bears a marked resemblance to Dumortier's figures[4] of the test of *Nautilus rugosus*, Buvignier[5]; but the Australian shell lacks the transverse lines, which Buvignier notes in the young of his species, and which Dumortier figures on a specimen 140 mm. in diameter. *N. rugosus* is, moreover, a much more compressed shell. According to Dumortier it is not very rare in the zone of *Ammonites armatus*. *Nautilus Jourdani*, Dumortier,[6] from the Upper Lias of England and France, differs from the Australian species by its sculpture and the angular margin of its umbilicus.

Locality.—Champion Bay, Western Australia.

AMMONOIDEA.

Ammonites (Dorsetensia, S. S. Buckman).

Ammonites (Dorsetensia) Clarkei, sp. nov. (Pl. XII. Figs. 2*a*, *b*, *c*.)

? 1870. *Ammonites radians*, C. Moore, "Australian Mesozoic Geology and Palæontology," Quart. Journ. Geol. Soc. vol. xxvi. pp. 230 and 232, pl. xv. fig. 2.

Sp. char.—Shell discoidal, compressed, evolute; greatest thickness at about the middle of the lateral area, nearly three-fourths of the height (breadth) of the whorl. Number of whorls unknown; inclusion small; umbilicus large, open, shallow. Whorl subquadrate in section, higher than wide, very slightly indented by the preceding whorl. Periphery sloping on either side from a small well-marked solid carina; in the cast the peripheral area is flattened, having a depressed band or rudimentary sulcus on each side of the carina; the inner whorls have a flattened peripheral area with a clearly marked sulcus on either side of the carina. Sides feebly convex; inner area imperfectly defined, slightly convex, sloping towards the umbilicus. Chambers moderately deep, in depth at the periphery nearly two-thirds of the height (breadth) of the whorl. Suture-line not very complicated; peripheral (siphonal) lobe narrow, fairly deep, with nearly parallel sides, divided by a rather low median saddle; first (superior) lateral lobe somewhat deeper than the peripheral (siphonal), trifid; second (inferior) lateral lobe small, trifid, scarcely one-half the size of the first lateral; a small auxiliary lobe; external (siphonal) saddle broad, divided by a small secondary lobe into two unequal parts, the smaller of which is towards the peripheral (siphonal) lobe; lateral saddle much smaller than the external

[1] Ann. Mag. Nat. Hist. [6], vol. v. p. 273, fig. 7. When the specimen here represented was figured the locality was not known, but Mr. Etheridge, F.R.S., in whose collection the specimen was originally, tells the writer that the "D" written in ink upon the specimen means "Dundry."

[2] Min. Con. vol. ii. p. 53, pl. cxxv. 1816.

[3] *Ibid.* p. 183, pl. clxxxii. 1817.

[4] Études paléontologiques sur les dépôts jurassiques du Bassin du Rhône, pt. 3, p. 54, pl. viii. ff. 3, 4; f. 3 especially.

[5] Statistique géologique, minéralogique, minérallurgique, et paléontologique du Département de la Meuse, 1852, Atlas, p. 46, pl. xxxi. ff. 23–25.

[6] Études paléontologiques sur les dépôts jurassiques du Bassin du Rhône, pt. 4, p. 44, pl. vii. ff. 1–5.

(peripheral). Test ornamented with ventrally-projected, subarcuate ribs, which (in the cast) are inconspicuous on the inner third of the whorl. The inner whorls are marked by forwardly inclined ribs, which (in the cast) are not very conspicuous on the inner area, though they appear occasionally to have crossed this area.

Dimensions:—

Diameter of shell	(estimated) about	60 mm.
Height of outer whorl		19 ,,
Thickness of outer whorl		13·5 ,,
Width of umbilicus	(estimated) about	26 ,,

Remarks.—This species is represented by a single specimen consisting of portions of three whorls of a shell about 60 mm. in diameter. The whole is septate and only a small portion of the test is preserved. The extreme length of the specimen along the periphery is 71 mm. At the central point the dimensions of the whorls are as follows:—

Height (breadth) of outer whorl	16·5 mm.
Thickness of outer whorl	11·5 ,,
Height (breadth) of preceding whorl (as seen in a lateral aspect)	7·0 ,,
Thickness of preceding whorl	7·5 ,,
Height (breadth) of next inner whorl (as seen in a lateral aspect)	3·0 ,,
Thickness of next inner whorl	4·5 ,,

Thus the combined height (breadth) of the three adjacent whorls is seen to be 26·5 mm.

The specimen figured by Moore under the name *Ammonites radians* most probably belongs to the present species. It has a diameter of about 60 mm., but, for the sake of comparison with the example just mentioned, the following measurements were taken at a point where the shell has a radius of 28 mm.:—

Height (breadth) of outer whorl	17 mm.
Thickness of outer whorl	10·5 ,,
Umbilicus of outer whorl	21 ,,
Height (breadth) of preceding whorl (as seen in a lateral aspect)	7 ,,
Thickness of preceding whorl	indeterminable
Umbilicus of preceding whorl	9 mm.
Height (breadth) of 2nd inner whorl (as seen in a lateral aspect)	2·5 ,,
Thickness of 2nd inner whorl	indeterminable
Umbilicus of 2nd inner whorl	4 mm.
Height (breadth) of 3rd inner whorl	1 ,,

It will thus be seen that at this point the combined height of the outer and two earlier whorls is the same as in the previous specimen, and that the relative proportion of the height of the whorls is almost identical with that in the incomplete specimen previously referred to. At the point where the septa are best seen, Moore's specimen is somewhat abraded, so that the true form of the suture-line is not displayed (see Pl. XII. Fig. 3).

Affinities and differences.—This species at once suggests a comparison with *Grammoceras*, Hyatt, and *Dumortieria*, Haug; both the character of the ornamentation and the general form of the suture-line suggest the division *Grammoceras* rather than *Dumortieria*. Mr. S. S. Buckman has, however, very kindly examined this specimen, and, in a letter to the writer, says: "It would be advisable to ascribe it to *Dorsetensia*. . . . . Its costation indicates either *Grammoceras* or one of the *Sonninin*æ; its septation—the tridactyloid character of

the superior lateral lobe is decidedly against *Grammoceras* and in favour of the *Sonninin*æ."

The species of *Dorsetensia* which seems to come nearest to the Australian fossil is *D. Edouardiana* (d'Orbigny),[1] but the latter can be at once distinguished by the form of its suture-line.

The present species comes very near *Grammoceras toarcense* (d'Orbigny)[2] and *Grammoceras striatulum* (J. de C. Sowerby),[3] two forms which have great resemblances, but which are regarded as distinct species by Oppel, Dumortier, and Buckman. The inner whorls of the Australian fossil possess a square peripheral area with a rudimentary sulcus on each side of the carina, and in this respect the specimen more nearly resembles middle-aged examples of *Grammoceras toarcense* (d'Orbigny) as described by Buckman, *Gram. striatulum* having an acute peripheral area at all ages. The ribbing, too, is like that of *toarcense*, but the whorls have no well-defined inner margin, and in this character the specimen resembles *Grammoceras striatulum* (J. de C. Sowerby). The suture-line is more ornamented than in *Grammoceras toarcense*, and approaches that of *Grammoceras Doertense* (Denckmann); but in the latter species[4] the first (superior) lateral lobe is not so deep, and the *lateral saddle* is neither so broad nor so rounded as in the Australian specimen.

The character of the suture-line distinguishes this present species from "*Harpoceras*" *pseudoradiosum*,[5] and "*Harpoc.*" *subundulatum*,[6] Branco, whilst the disposition of the inner part of the suture-line of the Australian specimen separates it at once from such forms as *Dumortieria grammoceroides*,[7] Haug, and *D. Levesquei*[8] (d'Orbigny), with which it has certain external resemblances.

Of the Ammonites which have been recorded from Australia, two only, viz. *A. Moorei*, Lycett,[9] or *A. Aalensis*, Zieten, var. *Moorei*, Lycett,[10] and *A. radians*, Schlotheim,[11] have any resemblance to the

[1] Pal. Franç. Terr. Jur. vol. i. 1842, p. 392, pl. cxxx. ff. 3, 4 (5?); S. S. Buckman, Inf. Ool. Amm. (Mon. Pal. Soc.), pt. vi. 1892, p. 304, pl. xlix. f. 4, and pl. lii. ff. 8–24.

[2] Pal. Franç. Terr. Jur. vol. i. 1842, p. 222, pl. lvii. D'Orbigny wrote the name as *Thouarsensis*, which spelling has been adopted by most authors except E. Deslongchamps, who wrote *Ammonites toarcensis*. Mr. S. S. Buckman [Inf. Ool. Amm. (Mon. Pal. Soc.), pt. iv. 1890, p. 172] adopts the spelling *toarcensis*, "since the name is taken from Thouars, a town in Deux Sèvres, of which the correct Latin name is Toarcium."

[3] Min. Conch. vol. v. p. 23, pl. cccexxi. f. 1.

[4] See Denckmann, "Ueber die geognostischen Verhältnisse Umgegend von Dörnten nördlich Goslar," Abhandlungen zur geologischen Specialkarte von Preussen und den Thüringischen Staaten, vol. viii. pt. 2, 1887, pl. viii. f. 4; pl. x. f. 9; and S. S. Buckman, Inf. Ool. Amm. (Mon. Pal. Soc.), pt. iv. 1890, pl. xxix. f. 3.

[5] W. Branco, "Der untere Dogger Deutsch-Lothringens," Abhandlungen zur geologischen Specialkarte von Elsass-Lothringen, vol. ii. (i.), p. 77, pl. ii. ff. 1–4.

[6] W. Branco, *ibid.* p. 84, pl. iii. ff. 3, 4, 5; pl. iv. f. 1.

[7] E. Haug, "Polymorphidæ," Neues Jahrbuch, 1887, vol. ii. pl. v. f. 5, and woodcut 6*c*, p. 137; and S. S. Buckman, Inf. Ool. Amm. (Mon. Pal. Soc.), pt. vi. 1892, p. 262, pls. xlvi. and xlvii.

[8] D'Orbigny, Pal. Franç. Terr. Jur. vol. i. 1842, p. 230, pl. lx.

[9] W. B. Clarke, Quart. Journ. Geol. Soc. vol. xxiii. (1867), p. 9.

[10] C. Moore, *ibid.* vol. xxvi. (1870), pp. 230, 232, pl. xv. f. 1.

[11] W. B. Clarke, *ibid.* vol. xxiii. (1867), p. 8; C. Moore, *ibid.* vol. xxvi. (1870), pp. 230, 232, pl. xv. f. 2.

present species. Both have been recorded from Western Australia. *Ammonites Moorei*, Lycett,[1] differs both as regards sculpture and the form of the suture-line; in fact it belongs to *Dumortieria*. As we have already remarked, the present species is most probably the same as that which Moore figured under the name *A. radians*, Schlotheim (*Nautilus radians*, Reinecke); a name which has been given to various species of Ammonites, as Mr. Buckman[2] has pointed out; the present specimen certainly does not agree with Reinecke's figure of "*Nautilus radians*."[3] We therefore suggest for the Australian species the trivial name *Clarkei*.

According to Mr. Buckman all the species of *Dorsetensia* are found in the *Humphriesianus*-zone, with the exception of two forms, which occur in the *Sauzei*-zone.

Locality.—Champion Bay, Western Australia.

Ammonites (Stephanoceras, W. Waagen).

Ammonites (*Stephanoceras*) *Australe*, sp. nov. (Pl. XII. Figs. 4*a*, *b*.)

? 1870. *Ammonites macrocephalus*, C. Moore, "Australian Mesozoic Geology and Palæontology," Quart. Journ. Geol. Soc. vol. xxvi. pp. 227, 232, pl. xv. f. 5.

Sp. char.—Shell (cast) discoidal, somewhat inflated, not very rapidly increasing; greatest thickness at about the middle of the lateral area, about two-fifths of the diameter of the shell; height (breadth) of outer whorl rather more than one-third of the diameter of the shell. Number of whorls and amount of inclusion unknown; umbilicus wide, fully one-third of the diameter of the shell in width. Whorl somewhat depressed, elliptical in section, a little thicker than high, slightly indented by the preceding whorl; periphery convex, a little flattened; sides convex, inner area rounded, imperfectly defined. Each whorl bears about twenty-five short umbilical ribs, each of which commences at the suture, extends with a slight forward inclination over the inner third of the lateral area, and terminates in a well-marked radially elongated tubercle. Each tubercle gives rise to two subangular (in the cast) ribs, which pass uninterruptedly over the periphery. Single ribs are occasionally interpolated between the pairs. There are about sixty peripheral ribs to a whorl, and on the periphery the interspaces are wider than the ribs. Suture-line unknown. Length of body-chamber unknown and aperture not seen.

Dimensions:—

Diameter of shell	62	mm.
Width of umbilicus *	24–	,,
Height of outer whorl	20	,,
Thickness of outer whorl †	24+	,,

* Too large, owing to distortion of specimen.
† Probably too small, owing to crushed condition of whorl.

Remarks.—This species is represented by only one example, which consists of the greater part of the outer whorl, somewhat damaged and distorted, and much obscured by the matrix on one side. The mouth-border is not preserved, and there is no trace of the suture-line.

[1] Lycett, The Cotteswold Hills, 1857, p. 122, pl. i. fig. 2. (The suture-line represented in fig. 2*a* does not, according to Mr. S. S. Buckman, belong to this species. Mr. Buckman gives the suture-line of Lycett's figured specimen in his Inf. Ool. Amm. (Mon. Pal. Soc.), pt. v. 1891, pl. xliv. f. 9.)

[2] S. S. Buckman, Inf. Ool. Amm. (Mon. Pal. Soc.), pt. iv. 1890, p. 188.

[3] Maris protogæi Nautilos et Argonautos, etc., figs. 39, 40.

The specimen from Western Australia figured by Moore as *Am. macrocephalus* is preserved in the Bath Museum. It has a diameter of 81 mm., but is so obscured by matrix that the other dimensions cannot be made out, except perhaps the thickness, which at the right-hand portion of the specimen as represented in Moore's figure is 31 mm. The very pronounced tubercle on the whorls gives rise to two well-marked ribs, and there is occasionally an intermediate rib. From the characters of the fossil, so far as they can be made out, the specimen would seem to be referable to the present species.

Affinities and differences. — Although resembling *Ammonites* (*Sphæroceras*?) *Woodwardi*, the present species differs in having a rather finer sculpture, less prominent primary (umbilical) ribs, and a somewhat larger umbilicus.

Unfortunately the suture-line of the Australian form is not available for comparison with other well-known species; but the present species is evidently closely allied to "*Ammonites*" *Braikenridgii*, J. Sowerby (Min. Con. vol. ii. p. 187, pl. clxxxiv.). An example of this species from the Inferior Oolite of Sherborne, Dorset (Brit. Mus. No. 98239), in its external characters, agrees remarkably well with the Australian fossil. It has the following dimensions: diameter of shell, 57 mm.; width of umbilicus, 26 mm.; height of outer whorl, 17 mm.; thickness of outer whorl, 22 mm.; with 27 umbilical, and 60 peripheral, ribs to a whorl. The present species has finer ornaments and shorter umbilical ribs than d'Orbigny's figure of *Amm. Braikenridgii* (Pal. Franç. Terr. Jur. vol. i. 1842, pl. cxxxv. ff. 3, 4); and coarser, less numerous ribs, much shorter umbilical ribs, and less inflated whorls than d'Orbigny's *Amm. linguiferus* (Pal. Franç. Terr. Jur. vol. i. 1842, pl. cxxxvi.); whilst the presence of a tubercle at the point of bifurcation of each umbilical rib at once distinguishes the Australian form from such species as *Amm. biplex*, J. Sowerby (Min. Con. vol. iii. p. 168, pl. ccxciii. ff. 1, 2).

Locality.—Champion Bay, Western Australia.

Ammonites (*Stephanoceras*), sp. (Pl. XII. Figs. 5*a*, *b*.)

Since this species is represented merely by a fragment it is not possible to give a complete diagnosis, but the following characters may be noted:—

Shell (cast) inflated; greatest thickness at the margin of the umbilicus. Umbilicus rather wide. Whorl (at the base of the body-chamber) obtusely cordate or almost lunate in section, nearly twice as wide as high; indented to about one-fourth of its height by the preceding whorl; periphery broadly convex and continuous with the sides; inner area sloping steeply towards the umbilicus and forming an acute angle with the convex surface of the shell. Suture-line imperfectly known. Whorl ornamented with a number of umbilical transversely-compressed tubercles, situated upon the prominent margin of the umbilicus; each tubercle giving rise to three ribs which, in crossing the convex surface of the cast, form a broad shallow sinus having its concavity directed backward. The tubercles are not continued over the inner area of the whorl.

Remarks.—The fragment representing this species is a natural cast in a ferruginous matrix of a portion of the body-chamber and of the adjoining chamber, the form of part of the penultimate

septum being seen at the posterior extremity of the specimen. One side of the cast is fairly well preserved; the other is much crushed and worn. The impressed zone, seen on the inner part of the whorl, shows that the ribs of the preceding whorl crossed the periphery without interruption. That the umbilicus was wide is indicated by the direction of the tuberculated margin of the fragment; this margin has five tubercles in a length of 38 mm. The maximum length of the specimen along the periphery is 80 mm. and its radius of curvature is 67 mm. Seventeen transverse ribs can be counted on the periphery; the interspaces are of about the same width as the ribs. The chamber adjoining the body-chamber was shallow, but, as this chamber is frequently much shallower than the rest, it may not represent the average depth of the chambers. The height of the whorl is 33 mm., the height above the preceding whorl being 27 mm.; the width was probably about 60 mm.

Affinities and differences.—The species represented by this fragment appears to be a close ally of *Ammonites sublævis*, J. Sowerby,[1] from the Oxford Clay and Kellaway Rock, having a particularly close resemblance to the middle-aged shell of this species from the British Callovian. But, judging from the fragment, the Australian fossil had a larger umbilicus and less numerous umbilical tubercles, and whilst in Sowerby's species the ribs arise usually in pairs from the margin of the umbilicus, in the Australian specimen each umbilical tubercle gives rise to three ribs.

The whorls of *Ammonites coronatus*, as figured by d'Orbigny,[2] have a much coarser ornamentation, a broader and flatter external area, and a narrower inner area than the Australian form; whilst *Ammonites Atherstoni*, Sharpe,[3] from South Africa, as represented by a specimen in the British Museum (No. 46534), has a smaller umbilicus, smaller umbilical tubercles, and very distinct, forwardly-directed ribs on the inner area of the whorls, *i.e.* on the sides of the umbilicus.

Ammonites Schenki, Oppel,[4] from the Jurassic of the Himalaya, has a smaller umbilicus, much more prominent umbilical tubercles, and less numerous peripheral ribs.

In sculpture the Australian form resembles *Olcostephanus latissimus*, Neumayr and Uhlig,[5] but it is a less tumid shell, and, so far as can be ascertained, has a different suture-line, its suture-line more nearly resembling that of *Ammonites Sutherlandiæ*, J. de C. Sowerby,[6] from the Calcareous grit, but the character of the ornaments at once distinguishes these two forms. The adult of the latter species is smooth, and the ribs on the inner whorls have a different direction from those of the Australian form.

Locality.—Champion Bay, Western Australia.

[1] Min. Con. vol. i. p. 117, pl. liv.
[2] Pal. Franç. Terr. Jur. vol. i. 1842, p. 465, pl. clxviii.
[3] Trans. Geol. Soc. [2], vol. vii. 1847, p. 196, pl. xxiii. f. 1.
[4] Pal. Mittheil. vol. ii. pl. 81, ff. 4*a–c*.
[5] Palæontogr. vol. xxvii. (1881), p. 158, pl. xxviii.
[6] Min. Con. vol. vi. p. 121, pl. dlxiii.

(*To be continued.*)

II.—Notes on the Pleistocene of the North-West Territories of Canada, North-West and West of Hudson Bay.[1]

By J. Burr Tyrrell, M.A., B.Sc., F.G.S.

In the extreme northernmost part of Canada, lying between North Latitudes 56° and 68° and West Longitudes 88° and 112°, is an area of about 400,000 square miles, which had up to the past two years remained geologically unexplored.

In 1892 the Director of the Geological Survey of Canada sent the writer to explore the country north of Churchill River, and south-west of Lake Athabasca; in 1893 the exploration was continued northward, along the north shore of Athabasca Lake, travelling from the east end of Lake Athabasca across the country in canoes to the west end of Chesterfield Inlet, and thence continuing in canoes along the shores of Hudson Bay almost to Churchill, from which place an overland journey was made to Winnipeg, Manitoba.

The south-western half of the country traversed in these two summers is more or less thickly covered with coniferous forest, while the north-eastern half is devoid of trees, and is generally covered with stunted grasses or lichens.

North of Churchill River the country is underlain by red and grey Laurentian granites and gneisses, with a fairly persistent strike in a south-westerly direction.

South of Lake Athabasca and Black River these Laurentian rocks are overlain by horizontal red sandstones and conglomerates, occasionally cut by trap dykes, which probably represent the Kewenawan sandstones of Lake Superior, and are therefore of Cambrian age, though no fossils were found in them. Athabasca, Black, Wollaston, and Cree Lakes lie along the line of contact of these sandstones and the underlying Archæan rocks.

The north shore of Lake Athabasca is composed of Laurentian gneiss, and Huronian quartzite, conglomerates, and schists, which in one place were found to be associated with a large deposit of hæmatite. The country crossed from Lake Athabasca to Doobaunt Lake is underlain by Laurentian gneiss, which, however, is often hidden by extensive deposits of Boulder-clay.

In one locality a small outline of unaltered fossiliferous Ordovician limestone was found, very similar in character to the white limestone of the Winnipeg Basin.

On Doobaunt Lake the Kewenawan sandstones and conglomerates were again discovered, and the country lying between this lake and the head of Chesterfield Inlet was found to be largely underlain by these rocks. The north side of Chesterfield Inlet is generally red and grey Laurentian gneiss, while the greater part of the shore of Hudson Bay for 150 miles south of the Inlet is composed of green Huronian schists cut by many quartz veins, and sprinkled through with particles of copper pyrites.

The whole of this region shows abundant evidence of having been comparatively recently covered with a mantle of ice, and even

[1] Published by permission of the Director of the Geological Survey of Canada.

to the present time Doobaunt Lake, the largest of the many hitherto unexplored lakes through which we passed, lying in North Latitude 63° and West Longitude 102°, and with an elevation of about 500 feet above the sea, seems to be always more or less completely covered with ice, for during the ten days which we spent on it—from August 7th to August 17th—we were obliged to travel in a narrow lane of water between the solid ice covering the main body of the lake and the shore, and in two places this channel was blocked by the ice resting against the beach.

In general physical features the "Barren Lands" often closely resemble the great plains west of Manitoba along the line of the Canadian Pacific Railway, being undulating grass-covered country, underlain by Till more or less thickly studded with boulders; but a hard granite knoll projecting here and there serves to remind one that the Till is not here resting on soft cretaceous shales and sandstones, and at once accounts for the much greater abundance of boulders.

In some places the surface is composed entirely of large subangular boulders, without any matrix of sand or clay, while the shores of Chesterfield Inlet, and part of the north-west coast of Hudson Bay, are bold and rocky.

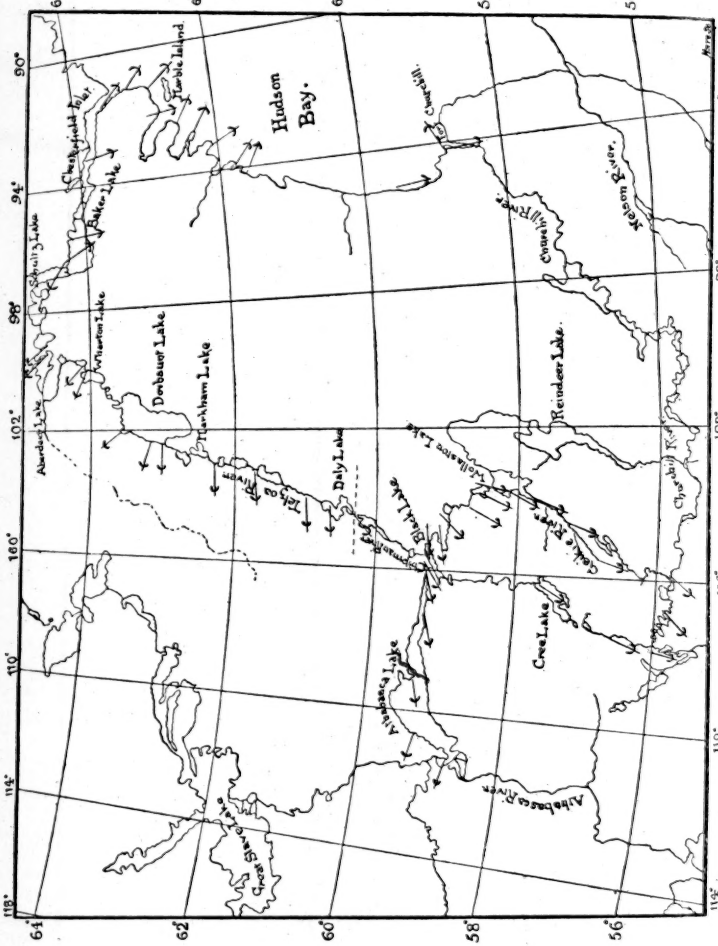
A particularly noticeable feature of the "Barren Lands" is the absence of valleys for the rivers. The Telzoa River, probably the largest stream in all that country, is, through the greater part of its course from Daly Lake to the head of Chesterfield Inlet, merely a succession of lakes of larger or smaller size, lying in original depressions in the Till or rock, connected by stretches of rapid water flowing in one or more shallow, tortuous, and often ill-defined channels frequently choked with boulders. Although the long winter and the ever-frozen ground would prevent very rapid erosion, it is evident that this river has been but a short time cutting out its channel.

Throughout the whole region the rock has everywhere been strongly glaciated, leaving the exposed portions rounded and often polished and striated. Most of the prominent knolls show clearly the direction of glaciation by the rounded stoss and broken lee sides, but in cases where two or three different glaciers have scored records on the small rocky knolls, all sides may be well smoothed, rounded, and scored.

The accompanying map shows the general directions in which the glacial grooves and striæ are trending, deduced from several hundred observations. As is there shown, the direction of glacial movement on the upper Churchill River is south or a little west of south, or parallel to the long axis of the lake; on Chipman River and the head of Telzoa River south-west; on Doobaunt Lake and the river in its vicinity west. Some of these last striations are crossed by an earlier set of striæ coming from the north.

On Telzoa River, between Doobaunt and Baker Lakes, the direction of striation is north-westward, the course being clearly shown by the stoss and lee surfaces, boulder trains, and the

crescentic cross-fractures in the grooves. At the west end of Baker Lake the north-westerly striation is crossed by what appears to be a local glaciation from the north, but this southward moving glacier soon obliterated all traces of the north-westerly one, and then the trend of the glaciation is found to be down Chesterfield Inlet, which



Map of the North-West Territories of Canada, explored by J. B. Tyrrell in 1892 and 1893. The arrows indicate the general direction in which the glacial grooves and striæ are trending.

is a rocky fiord with a depth varying from twenty-five to forty fathoms. The north-west coast of Hudson Bay, for 150 miles south of Chesterfield Inlet, is bold and rocky, and the hard Huronian rocks of which it is chiefly composed everywhere show well-defined glacial markings which have a general direction about S. 50° E. or directly out into the bay. Near the mouth of Egg River a boss of

coarse red granite on the shore is polished and scored with glacial markings trending southward. At Fort Churchill the low granite knolls, and the high bare rounded hills of green feldspathic quartzite, are scored by three sets of striæ, the two most recent of which are very distinct, while the earliest, wherever seen, is rather obscure. This latter trends N. 80° E. (or S. 70° W.?), and is not improbably merely an early variation of the next, which trends N. 55° E. This set of grooves and striæ is very strongly marked on all the southern and south-western slopes, against which the glacier pressed heavily on its way down the valley of the Churchill River to Hudson Bay, but the eastern sides of the hills show comparatively few traces of this glaciation.

Crescentric cross-fractures are common in the grooves, and these all lie with their concave sides towards the north-east, or towards the point of the compass to which the glacier moved. The most recent set of striæ is found on the summits and northern sides of the hills, and points southward, the striæ being found to vary from S. 5° W. to S. 10° E.

From the above record of striæ it will be seen that one of the great gathering grounds for the snow of the Glacial period in North America was a comparatively short distance west of the northern portion of Hudson Bay, and from that centre or gathering ground the ice flowed not only towards the Arctic Ocean and Hudson Bay, but it extended a long distance westward towards the Mackenzie River, and southward towards the great plains, while Hudson Bay was probably then to a great extent open water. From it the moisture would be derived which fell as snow near its western shore.

The older geology of the country is known over such a small portion of the total area that it is impossible to draw any definite conclusions from the direction of transportation of boulders; but on the west shore of Hudson Bay the boulders were such as would be derived from the Laurentian, Huronian, and Kewenawan rocks to the west, and there were no signs of the limestones, etc., from the islands in the Arctic Ocean or Hudson Bay. On the Telzoa River the boulders showed no evidence of having been derived from the west coast of Hudson Bay.

Drumlins or ridges of Till are almost everywhere found in the less rocky areas. Eskers are also common, either rising in high narrow elongated hills, or running as long sandy ridges, keeping their courses, which are parallel to the glacial striæ, over hills and through valleys and lakes quite regardless of the surface contour of the country. In the more southern districts these are wooded with large white spruce, which rise conspicuously above the stunted black spruce on the surrounding low land.

After the ice receded from the lower country the land was about 400 feet below its present level. On the lower side of a long portage a short distance below Doobaunt Lake the first well-defined raised beach and terrace was seen, and from that point all the way down the river to Hudson Bay old strand lines could be seen on the sides of all the prominent hills.

A white quartzite hill on the east side of Wharton Lake has three distinct gravel terraces or shore-lines on its southern side at heights of 60, 105, and 130 feet above the water. At the east end of Aberdeen Lake scarps, gravel, terraces, and ridges extend up the side of some hills of Kewenawan conglomerate to the height of 290 feet, the total series here having the following heights in feet above the water in the lake: 290, 220, 180, 150, 105, 90, and 60. On the side of a quartzite hill at the east end of Schultz is a well-marked gravel beach which the aneroid showed to have a height of 260 feet above that lake, probably the same as the 220 feet beach on Aberdeen Lake.

Similar raised beaches are found in favourable localities all along the shore of Hudson Bay.

These beaches indicate a gradual, though probably intermittent, rise of the land towards, or after the close of, the Glacial period; and some, even among the oldest of them, look as new as if they had been formed but yesterday, but it would seem that at Fort Churchill, and probably along the rest of the coast, the land and sea have reached conditions of comparative equilibrium. Some evidence on this point was collected near Fort Churchill, and especially at Sloop's Cove, a little bay on the north side of the river, where the ships of the Hudson Bay Company used occasionally to winter about the middle of last century. This spot was visited on the 29th of October and the 2nd of November of last year. The ice was in it then up to the level of an average spring tide, which had occurred two days before our first visit.

The cove is forty paces wide and one hundred paces long, and on each side are smooth well-glaciated hills of green quartzite rising to about 25 feet above the ice. At the back is a grass-covered bar of sand and gravel, joining the two disconnected hills of rock, and separating the cove from a wide flat that is flooded at spring-tide. The height of the summit of this beach was seven feet and a half above the level of the ice, or about the level of extreme extraordinary high tides. On the smooth glaciated surface of the rock many names and dates have been cut, some of which are given below, with their heights above the level of the ice :—

Furnace and Discovery, 1741	3 ft. 3 in.
J. Horner, 1746	6 ft.
James Walker, May 25th, 1753	7 ft.
Guilford Long, May 27th, 1753	7 ft.

and many others.

The "Furnace" and "Discovery," two small ships sent to discover a North-west passage, spent the winter of 1741–42 in Sloop's Cove, and left for the north as soon as the ice broke up in the spring of the latter year. Probably the names were cut in the almost vertical face of the rock by some one of the crew on whose hands the long days of waiting in winter hung very heavily. They are almost as high as a man would naturally reach if he were seated on a box or keg on the ice at the foot of the rock. The dates May 25th and May 27th opposite the names of James Walker and Guilford Long

would show that these names were cut when the ice was still solid in the cove, for the ice does not break up in the river at Churchill until the middle of June. These names were apparently cut by men standing on the ice when it was about two feet higher than it was last November, or when it was covered with two feet of snow. Nine large iron rings had been set in the rock at heights varying from two feet and a half to seven feet above the ice, just where they would be convenient to tie a small ship to at present, for the cove could not be entered, except at high tide. One other ring is fifteen feet above the ice.

All these signs of the winter occupation of this cove a century and a half ago are such as might be made at the present time, and are quite inconsistent with the theory that the rise of the land which took place in post-Glacial times is still going on at a comparatively rapid rate.

III.—On some Life Zones in the Lower Palæozoic Rocks of the British Areas, as defined mainly by Researches during the Past 30 Years.

By Henry Hicks, M.D., F.R.S., F.G.S.

(*Continued from the August Number, page* 371.)

Lower Cambrian.

UP to the year 1867 the only traces of organisms that had been found in the beds then classed as Cambrian by the Geological Survey (now Lower and part of Middle Cambrian of most authors) were tracks and burrows of Annelids; and the doubtful Trilobite *Palæopyge* found by Mr. Salter in the Longmynd rocks of Shropshire.[1] In "Siluria," fourth edition, 1867, p. 30, Sir R. Murchison refers to them as follows: "These, then, are the only signs of former life we have yet become acquainted with after the most assiduous researches in the Cambrian deposits of such vast dimensions, which are often, I repeat, less altered than much younger rocks replete with organic remains"; but, in the Appendix, p. 550, he says, "At the meeting of the Geological Society on June 19th, 1867, Mr. J. W. Salter read an account of the discovery of a minute *Lingulella* in the red Cambrian rocks of St. David's, which there underlies the 'primordial Silurian' (*mihi*). According to my view (and I am entitled to judge by acquaintance with both districts) the rock in which the fossil was found may be paralleled in age with the uppermost or red portion of my original 'Cambrian' of the Longmynd." This fossil was found by me in the red beds, below the *Paradoxides aurora* zone, which were then supposed to mark the Lower boundary of the Menevian Group, and in the paper communicated to the Geological Society, in which the account of its discovery is given, are the following remarks by Mr. Salter:[2] "Fossils in the red Cambrian rocks are so rare, that no apology seems due for introducing a single small specimen, lately gathered, after great

[1] Quart. Journ. Geol. Soc. vol. xii. (1856), and vol. xiv. p. 199.
[2] *Ibid.* vol. xxiii. p. 339.

research, by one of the authors of this paper. The search has been systematically pursued since 1862, when the first fossil of the Menevian Group was described by Mr. Salter from this neighbourhood; and the labour has chiefly fallen upon Mr. Hicks, who resides at St. David's. He has, literally, not left a stone unturned to find the true place of *Oldhamia*, and, if possible, of the mythical *Palæopyge* in these old red rocks. He has been rewarded, during the search, by many additions to the Menevian fossils, found at successively lower and lower horizons in the grey rocks which form the passage from the Lower to the Upper Cambrians. But, until quite lately, not a vestige had occurred to him in the actual red rocks themselves." I give these quotations as they clearly state what was then known in regard to the evidences of life in the so-called unaltered Cambrians as marked then and now on the Geological Survey Maps. The boundary line it appears was first adopted by Sir A. Ramsay when mapping the rocks in Pembrokeshire; for in the Geological Survey Memoirs, vol. iii., he says: "In 1841 the Geological Survey began to map the Silurian rocks at Haverfordwest, in Pembrokeshire, and Sir Henry de la Beche was unable in that neighbourhood to detect any base for the Silurian strata. In the same year, at St. David's, I traced a provisional line between the black and the purple slates, and this was afterwards adopted as the line between the Silurian and Cambrian strata." It was well known that the Cambrian as so defined contained in Pembrokeshire a great thickness of strata, with somewhat marked lithological characters; therefore it was but natural when the equivalent rocks in Merionethshire and Carnarvonshire were mapped in 1846 and 1848 that the Surveyors adopted the same name for these deposits, as "stratigraphically they occupy the same position, and lithologically they resemble each other."[1]

After the *Lingulella* was found by me in the red rocks, in 1867, I determined to search the underlying rocks systematically, and with much care, in the hope of finding still lower zones of fossils; and in the following year, 1868, I was able to announce at the meeting of the British Association that I had discovered several zones of fossils in the Cambrian, the lowest being 1200 feet below the red beds in which the previously described *Lingulella* had been found. The fossils, it was stated, occur usually at intervals in the strata; "scores, and sometimes hundreds, of feet of strata apparently intervening" between each zone. It was on this occasion also that I proposed that the "Menevian Group" should henceforth be included in Prof. Sedgwick's "Lower Cambrian" (the Cambrian of the Survey), owing to the much greater likeness between the fauna of the Menevian Group and the newly discovered fauna of the underlying beds, than between that of the former and the overlying Lingula Flags. The fossils found in these beds were subsequently described by me in the Quart. Journ. Geol. Soc. for 1871[2];

[1] Survey Memoirs, vol. iii. second edition, p. 8.

[2] "Descriptions of New Species of Fossils from the Longmynd Rocks of St. David's."

and for many years afterwards they remained the only organisms known in the Lower Cambrian rocks of Britain.

In the year 1881 I decided to divide the Lower Cambrian into three groups[1] under the names from below upwards of Caerfai, Solva, Menevian. I pointed out that it had a "natural base made up of massive conglomerates and sandstones," and that "its upper boundary is well defined by an important palæontological break," and that it is "clearly divisible at St. David's, where it has chiefly been explored of late years into three groups."

In speaking of the Caerfai Group I said that "beds of the same age are also found in the Harlech Mountains. The great slate quarries of Llanberis, Bethesda, and other places in Carnarvonshire are also on this horizon. Though the basal beds are not exposed in the Longmynd area, it is probable also that some belonging to this group occur there. There is a strong general resemblance between the beds of this group in each of the areas, but as they were at first shore deposits around a subsiding land-area, some differences in appearance and in thickness must necessarily occur."

In the year 1887 Dr. Woodward[2] described a *Conocoryphe* (*C. viola*), specimens of which had been found in the Upper Green Slates of the Penrhyn Quarries by Prof. Dobbie, and Messrs. R. E. Jones and R. Lloyd (two quarrymen employed in the Penrhyn Quarry, Bethesda, Carnarvonshire). This very important discovery of fossils in the undoubted Cambrian of the Geological Survey in North Wales, was hailed with delight by those who had been working in the Cambrian rocks in other areas, and it was hoped that additional fossils which would enable the horizon to be definitely fixed would soon be discovered. Up to the present, however, only one or two additional forms have been found in the quarry, and the horizon has mainly to be fixed by stratigraphical evidence. The *Conocoryphe* is undoubtedly of the type restricted to zones low down in the Cambrian; and, in my opinion, until further evidence is obtained, it may fairly be placed at as low an horizon as the base of the Solva Group of St. David's.

The stratigraphical sequence here, I described briefly as follows in the Report of an Excursion of the Geologists' Association to Penrhyn Slate Quarry and Nant Ffrancon in 1883 (vol. viii. No. 4):—

"In traversing this section from west to east, along the sides of Nant Ffrancon, the following general order of the rocks seemed tolerably clear:—

1. The purple and green slates of the quarry (Llanberis).
2. A thick series of grits and flaggy sandstones (Harlech).
3. Dark flaggy beds (Menevian).
4. Flags and sandstones with *Cruziana* (Lingula flags).
5. Dark flags (Tremadoc?).
6. Black slates and flags with pisolitic iron ore and grit at base (Arenig).

[1] "The Classification of the Eozoic and Lower Palæozoic Rocks of the British Isles," Popular Science Review, 1881, and Proc. Geol. Assoc. vol. viii. No. 5, 1881.
[2] Q.J.G.S., vol. xliv. p. 74.

In 1888, after another visit, Mr. J. Evans, F.G.S., a former Manager of the Penrhyn Slate Quarry, kindly furnished me with a careful statement of the succession made out in the tunnels, and in working the quarry, and the following table is mainly compiled from the details supplied to me by him. By its side I place also a detailed statement of the succession at St. David's :—

Nant Ffrancon, and Penrhyn Slate Quarry, Carnarvonshire.	St. David's, Pembrokeshire.	FEET	
14 Dark slates and flags (Menevian ?).	14 Dark flags and black slates (Menevian) . . . . . (*Paradoxides*, etc.)	750	
13 Grits and sandstones (Bronllwyd).	13 Grey, purple, red, and greenish sandstones, flags, and slates. (*Paradoxides*, etc.)	1800	Solva Group.
12 Green slates. (*Conocoryphe viola*, etc.)	12 Grits, sandstones, and greenish flags . . . . . (*Plutonia*, *Paradoxides Harknessii*, *Conocoryphe Lyellii*, *Microrrdiscus*, etc.)	150	
11 Purple slates.			
10 Purplish blue slates.			
9 Hard grits.			
8 Purplish blue slates.			
7 Grits.	7–11 Red and purple sandstones, flags, and slates	1000	Caerfai Group.
6 Red slates.	6 Red slates and flags . . . . (*Olenellus* fauna.)	50	
5 Purplish blue stripy slate.	5 Purplish flaggy sandstones . .	20	
4 Dyke (basic rock).	4 Dykes of basic rocks cut across the Lower Cambrian rocks at this and at various other horizons		
3 Green hard slates.	3 Greenish flaggy sandstones . . (*Olenellus* fauna.)	440	
2 Conglomerates (with large pebbles).	2 Conglomerates . . . . . (Many very large pebbles.)	60–150	
1 Pre-Cambrian rocks (felstones, etc.)	1 Pre-Cambrian rocks . . . . (Granite, felstones, volcanic ash, etc., etc.)		

As there are several faults in the quarry between Nos. 3 and 10, it is quite possible that some of the beds have been repeated.

It will be seen that there is a general resemblance in the succession in the two areas. At first, as the sea encroached on the pre-Cambrian land, the deposits would accumulate mainly in minor troughs separated by the higher plateaux and mountain ridges, and important differences in the thicknesses of the lowest Cambrian strata would necessarily occur even within limited areas. As depression went on oceanic conditions would prevail, and the sediments would become more alike over extensive areas. In a paper which I published in 1875,[1] I endeavoured to show the direction of encroachments of the sea, and of the migrations of the lowest Palæozoic faunas over the European areas, and in 1876[2] I entered more fully into this question in a discussion of the deposits as then known in

[1] Quart. Journ. Geol. Soc. vol. xxxi. p. 552.

[2] "Some Considerations on the Probable Conditions under which the Palæozoic Rocks were Deposited over the Northern Hemisphere." Geol. Mag. Dec. II. Vol. III. (April, May, and June, 1876).

the Northern Hemisphere. In this paper, page 157, I stated that "on both sides of the Atlantic they (the pre-Cambrian rocks) are to be seen at various places from the latitude of 30° to the Arctic regions, and it seems reasonable to suppose that these portions indicate parts only of what were probably two great continents extending over these areas, separated from one another by an intermediate ocean, narrower considerably than the present Atlantic, but still occupying part of that basin. When these continents commenced to subside, the parts facing the Atlantic were the first to become submerged." [1]

The great thicknesses found in some areas show that there must have been much loose material on the pre-Cambrian land ready to be washed off as each part became depressed, and an examination of the sediments shows very clearly that much of the material came from the volcanic rocks and cones of the pre-Cambrian period.[2] Angular fragments of volcanic rocks occur so frequently, mixed up with other sediments in the Lower Cambrian rocks, that it seems clear that such loose materials remained on the higher ridges and plateaux after adjoining areas had been depressed to a considerable depth; and the incoming of these materials along with other rough sediments, usually at fairly definite horizons, mark frequently the vertical limits of certain organisms in these areas.

At the meeting of the International Geological Congress in London in 1888, Mr. C. Walcott, of the United States Geological Survey, made the very important announcement that he had recently discovered in a very complete section of the Cambrian rocks at Manuel's Brook, Newfoundland, that the *Olenellus* fauna occurred below the *Paradoxides* fauna, and not above, as had up to that time been supposed to be the case in America. In Sweden and in some other areas in the N. of Europe it had been previously shown by Doctors Linnarsson, Brögger, Holm, and Schmidt that the *Olenellus* fauna was the oldest; but until Mr. Walcott showed that the order of succession was similar in America, it had not been taken as of general application. Mr. Walcott now proposed also that the Cambrian should be divided into three parts, viz. the *Lower*, characterized by the *Olenellus*, the *Middle* by the *Paradoxides*, and the *Upper* by the *Olenus* fauna, and this classification has since been very generally adopted. Previously in Wales we had divided the Cambrian into two main parts, viz. a *Lower* containing the *Paradoxides* and earlier faunas, and an *Upper* the *Olenus* fauna. I had, however, as already shown, subdivided in 1881 the then Lower Cambrian into three groups, viz. Caerfai, Solva, and Menevian; and in the year 1892 [3] I was able to show that the *Olenellus* fauna at St. David's was confined to the Caerfai Group. Here the *Paradoxides*

[1] Mr. C. Walcott has recently worked out with much care the evidences of the early conditions prevailing during the same periods on the American continent ("The Fauna of the Lower Cambrian or *Olenellus* Zone," 1890, and "Bulletin of the United States Geological Survey," No. 81, 1891).

[2] See "Pre-Cambrian Volcanoes and Glaciers," Geol. Mag. Dec. II. Vol. VII. (November, 1880).

[3] Geol. Mag. Dec. III. Vol. IX. p. 22.

fauna extends through a great thickness of strata, as I shall be able to show when I refer more particularly to the Middle Cambrian. Almost immediately after Mr. Walcott's announcement was made, Prof. C. Lapworth published a highly interesting account of the discovery by him in Shropshire of the *Olenellus* fauna, and he there states that "the presence of traces of the *Olenellus* fauna in the West of England" was known to him for some time, the first recognisable fragments having been detected by him "on the flanks of Caer Caradoc in 1885, but they were too imperfect for description." Better material had by this time been obtained, and he was now able to give the provisional name of *Olenellus Callavei* to one of the forms, and to add several other fossils known to be characteristic of the *Olenellus* zone. He further says[1] that "this Lower Cambrian or *Olenellus* formation of the Shropshire area consists of two main members, viz. the basal quartzite of Lawrence Hill and Caer Caradoc, and an overlying green sandstone, the Comley Sandstone (Hollybush Sandstone of Dr. Callaway). This formation follows unconformably upon the so-called Uriconian rocks of the district, and occurs in many localities, as at Lilleshall, the Wrekin, Caer Caradoc, Cardington, etc."

In the Geological Magazine for December, 1891, Prof. Lapworth published a full description of *Olenellus Callavei*, with figures; and stated that in Shropshire, as elsewhere, "we find the Cambrian divisible into three sections—an Upper Cambrian above, marked by the presence of the genus *Olenus* (Olenidian); a Middle Cambrian group with *Paradoxides* (Menevian or Paradoxidian); and finally a Lower Cambrian (*Olenellus* zone) or basal group (possibly of somewhat different systematic importance), distinguished by the presence of *Olenellus*." At the meeting of the British Association in 1891, Sir A. Geikie announced the discovery of *Olenellus* by the Geological Surveyors in the North-West of Scotland, and since then additional species of that genus have been obtained by them as well as some of the usually associated organisms. This important discovery of typical Lower Cambrian fossils overlying Torridon Sandstone proved that the latter must be of higher antiquity, hence of pre-Cambrian age. Up to the present time the usually overlying *Paradoxides* and *Olenus* zones have not been found in Scotland. It seems pretty evident that the Cambrian rocks must be comparatively thin in the North-West of Scotland; in this respect simulating the succession in Scandinavia rather than that in Wales.

There can be no doubt that the genera *Olenellus*, *Paradoxides*, and *Olenus* in the areas where they have been found to succeed each other in conformable sediments do mark very definite periods in the world's history; but such arbitrary lines are not natural, and we must expect to find from time to time that the limit assigned to a genus will have to be extended as new areas are being explored. Where a genus, which has been sufficiently abundant to characterize a main zone, disappears suddenly, there is usually some indication in the deposits of at least a slight physical change. At St. David's

[1] Geol. Mag. Dec. III. Vol. V. p. 485, and "Nature," vol. xxix. p. 213.

this is particularly marked, for immediately below the lowest *Paradoxides* zone a fine conglomerate containing angular fragments of volcanic material occurs, and this I have taken as the boundary line between the Caerfai (*Olenellus* beds) and the overlying Solva (*Plutonian* and *Paradoxides* beds). Again, at the top of the Menevian, and separating it from the overlying Lingula flags (*Olenus* beds), massive grits succeed black slates, and in these grits we again meet with volcanic materials. Were it not for these changes I doubt not the genera would have a greater vertical range, and at certain horizons also intermediate forms would be found. In naming groups of strata after a genus there is, of course, the danger that the prevailing genus in one area may not be so in another, and may indeed be entirely absent, though the beds may be of exactly the same age. Still, as already stated, other associated fossils are usually equally characteristic of the zone, therefore there is not, as a rule, much difficulty in defining the horizon even when the stratigraphical evidence is incomplete. In Wales there are many exposures of Lower Cambrian rocks which would be likely to yield fossils to a careful search, and I feel confident that, ere long, they will yield a much richer fauna than has hitherto been obtained from them.

(*To be continued.*)

IV.—The Most Recent Changes of Level and their Teaching. The Rapid Collapse of Some Districts at the Close of the Mammoth Age.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

In some recent papers published in the Geological Magazine, I have endeavoured to show that at the close of the Mammoth age there was a very considerable dislocation of the earth's crust, and that a consequence of it was the upheaval of some of the highest masses of land on the earth, including the massive mountains of Asia and the American Cordillera. I now propose to show that (as is *à priori* probable) there was a concurrent collapse or sinking of the ground over large areas, which, as in the corresponding upheaval, was very rapid, if not sudden.

We will begin with our own latitudes. There cannot be any doubt that in the Mammoth age England was joined to the Continent. This, I presume, is accepted by everybody. We cannot account for the presence here of the Pleistocene and existing Mammals by any other postulate than the existence of a land-bridge when the Mammoth and the Tichorhine Rhinoceros were living on both sides of what is now the Channel.

This is plain. Where was this bridge? Was it a continuous stretch of land entirely occupying the English Channel, as has been generally supposed, and as has in consequence been figured on many maps; or was it a much more partial one, forming an isthmus. In my view there can be little doubt it was the latter. In the great headland at Selsea, Godwin-Austen has described large portions of the skeleton of a Mammoth as found mixed with

marine shells in the same bed. I can only explain this by supposing that the English Channel in the Mammoth age was open at least as far as the longitude of Selsea; and as these shells contained a number of Lusitanian species, it means that the English Channel was then open to the west and south-west, whence these shells must have come. This is confirmed by the further fact that, so far as I know, no Mammoth remains have ever been dredged in the Channel west from this point, except close inshore in Torbay, etc. How much further eastward than Selsea the open water extended I do not know. A Mammoth tooth has been dredged on the oyster banks off Calais, and another in the channel separating the Vorn sand-bank from its neighbour. This last is the furthest west in the open channel that I know of any such remains having been found under the sea, and the two banks perhaps mark the western edge of the land. When we approach *the eastern* entrance to the Channel we begin to find ample evidence of the land-bridge we have been talking about. Between Dunkirk and Cromer we can draw a line which passes through an area where the whole sea-bottom was once strewn with Mammoth bones and teeth. The majority of them have been cleared away by the dredgers. Most of them have been broken and destroyed; but the Owles Collection in the British Museum is a splendid trophy, "*spolia opima*," from this cemetery, as the fishermen call it. We can put our dredges upon the actual land-surface which then existed and bring up in them the remains of the animals which lived on it, fresh, unweathered, and sometimes even articulated, as is the case with specimens I have by me, and many specimens in the Owles Collection, and in the collections at Norwich, etc. The sharp edges of the muscular attachments in all these bones and teeth show they were never exposed to the weather nor rolled by the sea, and that they must have remained where the animals fell from the time they fell until now. That these bones are the *débris* of carcases floated by the rivers I do not for a moment believe. Rivers do not float carcases out to sea in this way, and if they did, these carcases are quite out of the way of any possible river-current of any known rivers. When occasionally animals are drowned in rivers they are speedily pulled under by the carnivorous fish, etc. The vast cemetery of Mammoths and other animals existing between Norfolk and Dunkirk has all the appearance of a stretch of land which suddenly sank, and was thus submerged, with all its living inhabitants.

What the northern boundary of this isthmus was we cannot positively say. If it be permissible to borrow an argument from ornithology, we may fix it at a line joining the mouth of the Elbe and Norfolk; for it is here that the famous migrating line of birds is placed, and the ornithologists tell us they can only explain it by supposing that this was the former limit of land and sea. Here, then, we have the rude outline of the bridge over which Mammoth and Rhinoceros, Bison and Irish Elk, with their contemporary Palæolithic Man, travelled from the Continent to Britain. This same isthmus would also separate the cold waters of the North Sea, whose

temperature is attested by the so-called glacial shells found on the north-eastern coast of England, and the eastern coast of Scotland, from the warmer waters of what is now the English Channel, whose temperature is similarly attested by the shells found at Selsea.

S. V. Wood, jun., speaking of the Selsea beds, says "they contain a marine fauna quite unlike that of any post-Glacial marine beds in England and Scotland, and consisting of species, all of which are living. Nearly all the shells live on the south coast, but a few do not now reach us, but have their northern limit on the Lusitanian coast; so that the English Channel at some post-Glacial time (? post-Glacial, H. H. H.) was subjected to an influx of Lusitanian water, which afterwards ceased when the Lusitanian shells disappeared."

The disappearance of the Lusitanian shells can be explained, most rationally as it seems to me, by the breakdown of the isthmus in question, which would allow the cold waters of the North Sea to circulate into the Channel, and thus lower the temperature of its waters.

In the collapse of this land-bridge we have some evidence of the considerable subsidence which took place at the close of the Mammoth age. If we travel westward it is almost certain that the separation of the Isle of Wight from the mainland took place at the same time, for the remains of the Mammoth and its companions have been found there as on the mainland.

Further west the evidence is more definite. Round the coasts of Dorsetshire, Devonshire, Cornwall, and Somerset, there have been found large remains of submerged forests, and both in Torbay and Bideford Bay, on the two sides of the great western English promontory, there have occurred Mammoth's teeth, apparently derived from these beds. These clearly point to a considerable submergence of land in the west country after the Mammoth time, and, as the teeth and bones are unweathered, it would seem to follow that it was immediately after the destruction of the Mammoth that the submergence took place. A similar conclusion was arrived at by Dr. Falconer and the explorers of the Gower Caves, who concluded that it was impossible for herds of great herbivorous animals to live in a district like that in which the Gower Caves are situated, unless its condition was very different, and that the facts point to the submergence of a considerable extent of champagne country at the close of the Mammoth era in the district now occupied by the Bristol Channel.

If we now turn to the Irish Sea we shall have reason to come to the same conclusion. In the middle of the Irish Sea is the Isle of Man. In the Isle of Man have occurred remains of the great Irish Deer in the marls underlying the peat bogs. Similar remains have occurred in Great Britain, and of course in Ireland, and they mean that a land-bridge must have existed connecting the three areas. That this land-bridge existed in the Mammoth age we cannot positively say, since no Mammoth remains have hitherto occurred, I believe, in the Isle of Man, and there is some doubt as to whether the Irish Deer did not survive the Mammoth period in Ireland. But

the probabilities are very greatly in favour of this bridge having existed at the time when the Channel bridge was broken.

The exact position of this land-bridge we cannot absolutely ascertain at present, but we have some guide. The peculiar fauna of Ireland points to its having been united to Great Britain, not in the south but in the north. The birds of Ireland are especially noteworthy in this respect, and ornithologists in fact treat Ireland as a province of Scotland. The same conclusion is pointed at by the scarcity of the remains of the Mammoth in Ireland, and the absence of the Tichorhine Rhinoceros there, the identity of the Irish Hare and the Scotch Blue Hare, etc.; and it would seem, therefore, almost certain that this bridge was situated in the north of the Irish Channel, while the south of the same sea was occupied as now by water; and we have some evidence that the Molluscan fauna of Moel Tryfaen and of the Lancashire and Macclesfield beds, and also of the Irish Pleistocene beds, is of a more temperate character than that of the beds of the same age in the west of Scotland, pointing to a separation between the waters of the Irish Sea and those bathing Western Scotland having once existed.

That some changes of level have taken place, however, in the southern part of the Irish Sea, involving a considerable subsidence, we know, from the buried forests, etc., in Cardigan Bay, while the junction of Anglesea to the mainland in the Mammoth age seems attested by the well-known molar tooth discovered by Mr. Owen Stanley in a submerged peat bog.

If we turn to the other side of England, evidence of a similar kind is forthcoming. We have remains of submerged forests off the coast of East Anglia and Yorkshire which cannot be explained by any other theory than a widespread submergence; the same conclusion follows from the semi-fossil *littoral* shells which have been dredged in the North Sea, and which show that there must have been shallow water where there is now deep.

Let us now cross over the North Sea. The coasts of Denmark are girdled with traces of submerged forests, so are the southern shores of the Baltic. Similar traces have been found in the Sounds separating Sweden and Denmark. Here we seem to be on traces of a comparatively recent change of level, since at least one polished stone axe has been dredged in the Cattegat. But even better evidence of such a submergence is the comparatively recent existence of the *Bos primigenius*, and perhaps the Bison, on both sides of the Sounds and its absence in Central and Northern Sweden, in Finland, etc. Its remains have been found in the turbary deposits of Scania, while they abound in Mecklenburg, and there is no way in which we can account for this animal occurring in both areas except by a land-bridge.

If we now turn to the plains of Holland and North Germany, we shall have evidence of another kind. The Drift deposits lie there in some places to a vast depth, and it has been remarked, that if they were removed, a very large area would be under the level of the sea; this, too, where there are no traces of marine

beds below the Drift, but every evidence of continuous land conditions. This old land-surface, with its living occupants, points unmistakably to the general level having been considerably higher very recently.

Let us now turn to another district. I have already in previous articles discussed the more recent history of the Arctic border lands of North-Eastern Europe and Asia, and have shown that while in the Mammoth age the Bear Islands were united to the mainland, there was also a land-bridge between Asia and America by which the animals could pass to and fro. In either case this was followed by a great collapse along the whole sea-board, by which a large strip of land was submerged. The evidence of this is two-fold, namely, the occurrence of large numbers of bones between the Bear Islands and the mainland, where they have been dredged; and secondly, the occurrence of marine shells far inland in the valleys of the Petchora, the Obi, and the Yenessei, showing quite a recent elevation. In some cases these marine beds overlie the Mammoth beds and thus enable us to fix the fact that the last upheaval has been more recent than the last submergence in those latitudes. If we turn to the eastern coast of Asia, and examine the fauna and flora of the Island of Saghalien and the Northern Island of Japan, separated from the Southern Island by that great zoological "divide" Blackeston's Line, we shall be constrained to the conclusion that these two islands, forming so integral a part of the Palæarctic region, can only very recently have been separated from the mainland, and that we have here, as in the broken bridge of Bering Straits, fresh evidence of a great and recent collapse of the land.

If we turn to America, we shall find some of the most experienced geologists in agreement as to there having been a very recent much higher continental elevation there. This is shown by the submerged valleys. Thus Prof. J. W. Spencer calls attention to the fact that the original rocky floor of the Mississippi valley is buried to a depth of 170 feet at La Closse, 1000 miles from the Gulf of Mexico; while at New Orleans the boring of 630 feet below the sea-level does not penetrate the Southern Drift, nor even reach to its highest members; this, as he says, points to the fact that the country drained by the upper waters of the Mississippi must have stood many hundred feet higher than it does now relatively to the region at its mouth, while that same region has also been greatly elevated. "Passing," he says, "from the buried channels of the Mississippi to its continuation, now submerged beneath the waves of the Gulf of Mexico, we find evidence indicating such a stupendous continental elevation as to be almost incredible were it not supported by collateral evidence upon both the Pacific and Atlantic coasts. The surroundings off the coast of the delta of the Mississippi indicate the outer margin of the continental plateau as submerged to a depth of 3600 feet, indented by an embayment of another hundred fathoms in depth, at the head of which there is a valley, a few miles wide, bounded by a plateau from 900 to 1200 feet above its floor. This

valley is now submerged to a depth of over 3000 feet, and is the representative of the channel of the ancient Mississippi River, towards which it heads."

On the Pacific coast, in the region of Cape Mendocino, Professor George Davidson has identified three valleys, now submerged, from 2400 to 3120 feet, and several of inferior depth. These measurements are those of the valleys where they break through the marginal plateaux of the continent at about six miles from the present shore, where it is submerged to the depth of a hundred fathoms. Similar deep fiords exist on the Atlantic sea-board; that of the Hudson River is traceable to the margin of the continental plateau, requiring a depth of 2844 feet; similarly the Delaware River valley is continued by another fiord, the floor of which is now covered to a depth of 1200 feet, its continuation seaward not having been ascertained; so with the St. Lawrence and the Saguenay. Similar evidence of former elevation, according to Mr. Spencer, is also shown by the great depths of the American lakes. Turning elsewhere, Professor Le Conte has shown that the islands south of Santa Barbara and Los Angeles on the Pacific coast of the United States, which are separated from the mainland, and from each other, by channels from 20 to 30 miles wide, and 600 to 1000 feet deep, were still a part of the mainland during the late Pliocene and early Quaternary periods. Mr. Upham calls attention to the submerged valleys in California, and right away to Alaska, as pointing the same lesson. Travelling elsewhere again, it is impossible to doubt, if we examine the biological evidence, that the Island of Ceylon has been quite recently united to the peninsula of India; so with the islands in the Gulf of Bengal. In a recent number of "Nature" we have an account of the discoveries of the remains of an Elephant in a little island in that gulf, showing that it also must have been very recently joined to the mainland. We cannot explain the problem of the fauna of Sumatra, except by supposing that it has been very recently indeed separated from the Malay peninsula. Nor do I know anyone who doubts, since the researches of Wallace, that the Eastern Archipelago has been the scene of a very recent dislocation and subsidence. The same kind of evidence compels us to postulate the very recent sinking of the channel between Tasmania and Australia; the fauna of the two areas being so conspicuously alike, while that of the former is marked by the presence of more than one living animal now extinct in Australia, but existing there in Pleistocene times. I might continue this examination farther, and easily enlarge the number of cases, proving unmistakably that at the close of the Mammoth age there was a great subsidence of the earth's crust in many latitudes.

I have argued in previous papers that it is equally clear that some very important mountain chains were very rapidly, if not suddenly, elevated at the same period, so that the subsidence here postulated would only be the complement of elevation elsewhere.

I do not know that the facts of such a subsidence would be seriously contested provided it were granted that it were slow and

continuous, but this slowness and continuity I cannot concede. I do not find evidence anywhere that is satisfactory that the earth, since it became solid, has behaved like a great mass of dough, swelling here and subsiding there by continuous movements; on the contrary, it seems to me that wherever we have evidence of such movements, and surely it is ample enough, that evidence points to its having been by jumps and starts, involving great fractures and dislocations, reversals and breaches of continuity. Just as I ventured to argue that the upheaval of the Ural Mountains, of the Altai, and of the American Cordillera was rapid, if not sudden, and marked by every sign of cataclysmic change, so also do I hold the corresponding subsidences to have been rapid, if not sudden. Evidence on such a point is not always easy to find, but in some cases it seems to me to be patent and conclusive, and I would quote them as samples of the rest. Take the Channel Bridge, to which I have already referred, or the sea-bottom between the Bear Islands and Siberia, or the submerged forests occurring on many coasts. How is it possible to understand, if the remains of these old land-surfaces were submerged by slow and gradual sinking, that the sea with its sharp chisels and hammers did not break down and wear away to powder every Mammoth tooth and bone, and every tree trunk. Instead of this, as I can testify from many examples in many places, especially in regard to the bones and teeth referred to, every slight ridge and muscular attachment is beautifully preserved, and there is no sign whatever of weathering. The bones are as sharp as the day they were deposited, not in one place only, but over wide areas. We cannot escape the conclusion that the land-surfaces on which they lie, which are entirely out of the reach of any river portage, were rapidly submerged, and thus protected from the gnawing tooth with which the ocean between high and low water-mark grinds hard rocks as well as soft ones into gravel, sand, and mud. The same argument applies to the submerged forests and beds of soft and easily eroded clay in which the trees are often rooted. Here, also, I cannot understand how such beds could have survived the battering of shingle and tide if they had been gradually submerged, as some have argued. This is not my view only, but has been held by much better men than myself, Godwin-Austen, Murchison, and others.

To quote one of them, Murchison, "it cannot surely be maintained," he says, "that by the ordinary action of the sea and a gradual depression of the lands now sunk beneath the Irish Channel, England and Ireland were separated since the gigantic Elk (*Cervus magaceros*) inhabited our lands. Nor by such gradual agency only can we even account for the formation of the great channel which now separates England from France. My firm belief, indeed, is that these separations were effected in the first instance by powerful breaks of continuity, caused by much grander earthquakes than any of which history affords a record, due to expansive internal forces, which gave rise to great upheavals and subsidences in the crust of the earth. In more remote periods, or those of older geological date, these forces have, we well know, produced still more intense

disruptions, and have even abruptly thrown enormous masses of hard pebbly sediment under the rocks out of whose detritus they have been derived" (J.R.G.S. vol. clxv.–vii. p. 33).

The burden of the parable which I have been trying to preach in this paper is that the catastrophe which involved the destruction of the Mammoth and some of its companions involved not only the upheaval of some important mountain chains, but the corresponding subsidence of large areas in different parts of the world, both movements having been sudden and cataclysmic. This conclusion explains two facts which need explanation. In the first place it affords a good and ample cause for the diluvian movement which I have so often postulated, and which was deemed necessary by geologists of as great distinction, acuteness, and experience as any now living, and whose wisdom time will presently vindicate. It also explains that form of the Glacial theory which an increasing number of geologists are supporting, namely, the existence at a recent geological date, not of portentous ice-caps and ice-sheets caused by goodness knows what, and completely at issue with the laws of mechanics and the deductions of astronomy, but of much larger glaciers where glaciers still exist, and of the recent existence of glaciers where glaciers no longer exist. This result, some of us think, was due to changes within the earth itself, and not to astronomical causes. Geographical reasons suffice to create a climate at this moment at Yakutsk far exceeding in severity any climate at places on the same latitude which purely astronomical causes could induce. I believe that geographical changes of a similar kind would suffice to build up the great glaciers of Pleistocene times. If the British Isles were upheaved, so that a large part of the Irish Sea and of the German Ocean were above the sea-level it seems not improbable that the mountains of Scotland and of Wales would nurse glaciers of their own. If this elevation extended, as some very acute French geologists have urged, to Switzerland, the glaciers of the Alps would be correspondingly enlarged; so with Scandinavia. If the United States and the country to the north stood in Pleistocene times several thousand feet higher than they do now, it would invariably follow that the Laurentian highlands and the mountains of British Columbia would nurse, as the evidence shows they nursed, large glaciers also. If Tasmania were joined to Australia by the process of the general upheaval of the land in those regions, there is no difficulty in understanding how the mountains of Western Tasmania and of Victoria should also have had glaciers of their own. Thus the postulate we stand upon explains the facts as we read them. Of course it explains them on the supposition that Sedgwick, and Conybeare, and Murchison, and d'Archiac, and many other heroes of our science were not children at their work, but acute and experienced philosophers, when they argued that catastrophe is an indispensable factor in unravelling the riddle of the earth. It also involves a breach with those modern teachers of our science who, while professing to be shocked at the very sound of the word cataclysm, do not scruple to raise up continents

and to sink them again, in order to explain a few rounded pebbles on the isolated flank of a hill, and make ice travel by some properties unknown to experience over hundreds of miles of level country, scraping the rock as it marches, and yet carrying under its gentle slipper several hundred feet thick of soft clay and sand, and sometimes delicate and fragile shells. I do not understand, and feel bound to protest against, the continual appeal of the modern school of geology to causes which have not been verified; and it seems to me like trying to turn the flank of the north wind by an appeal to the east wind, when a geologist, in order to save a mere scholastic formula, such as Uniformity, ignores the laws and conditions of science.

V.—Some Physical Questions Connected with Theories of the Origin of Mountain Ranges.

By T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

MR. A. VAUGHAN has honoured with a criticism[1] my exposition of the physical principles upon which my Theory of the Origin of Mountain Ranges is founded, which appeared in this Magazine last May.[2]

Had it not been that much of what I have written seems to have been misapprehended, I should probably have refrained from comment and left the two papers to speak for themselves.

If Mr. Vaughan will refer to my "Origin of Mountain Ranges," which has been before the scientific public for eight years, he will see that chap. xi., while dealing with "the Hypothesis that Mountain Ranges are ridges thrown up by the Compression induced in the rigid Crust of the Globe by a Shrinkage of the heated Nucleus," was written to show that the ideas then prevailing on the effects of secular contraction were inaccurate, and in this chapter the conception of the existence of a level-of-no-strain was first developed. Further, to quote my own words, I say: "If the above reasoning be valid, it is plain that whatever compression may take place in the crust of the globe must be confined to a very slight depth below the surface; *to such a thin stratum*, in fact, that the ordinary denudation constantly going on would probably obliterate most of the resultant corrugations."[3]

In the contrast I have drawn from time to time between my expansion theory, and the older one of secular contraction, I have studiously given the latter theory the benefit of maximum figures in order to prove up to the hilt that the expansion theory gives the most effective explanation of geological facts as we find them. I join issue with Mr. Vaughan, however, in his calculation of the amount of material which the compression of the outer shell, according to my figures, would give for mountain-making. It would not exceed on the most favourable conditions one twenty-third of the amount he states (p. 316). Also as a practical result such surplus material could not possibly be all used for mountain-making, much

[1] Geological Magazine, July, 1894, pp. 312–320.
[2] *Ibid.* pp. 203–214. [3] Origin of Mountain Ranges, p. 125.

less be concentrated in one spot; some of it would go to thicken the earth's crust.

Mr. Vaughan calls in question the principle adopted by me of ascertaining the radial contraction of the earth under the conditions assumed by me. The method, of course, is only a rough one, but when we are dealing with quantities which cannot be established with great accuracy the rough method is the safest. I take the direct linear radial contraction across the contracting shells, and multiply that by three. A little consideration will show why the linear contraction across the shells is not a true index of the earth's contraction as a whole. The shells are stretching themselves over a nucleus that remains of a nearly constant diameter, therefore they are thinning themselves by *stretching*, as well as by radial contraction. To put it in other words: A voluminal contraction is a contraction of a given volume along three axes at right angles to one another—this will be expressed roughly by a figure three times the linear contraction. When, however, a shell of rock contracts over an unshrinking sphere below, contraction along two of these axes being impossible, the whole effect is concentrated on the third and becomes a linear contraction—roughly, three times the linear contraction proper for the rock; of course being accompanied by tensile stresses and deformation of shape.

Having had considerable difficulty in following Mr. Vaughan's reasoning respecting his own theory, I may possibly have misapprehended it as he has mine in the cases just dealt with.

To put it shortly, his may be called a *tensile* theory. Before such a theory could be established it would be necessary to show that the tensile strengths of the materials of the earth are sufficient to stand the stresses this theory puts upon them. It appears to be part of Mr. Vaughan's theory that the outer crust has not been able to withstand the tensile stress put upon it by shrinkage through loss of heat, and is consequently full of fractures. How then could the underlayers by shrinking exert such a huge pressure on the interior as to actually compress the materials of the earth into a smaller volume? Is the tensile strength of any of these underlayers equal to that of steel? We know that 30 tons to the square inch is about the breaking strength of steel. It would be interesting if Mr. Vaughan or some other mathematician would work out the decrease of volume which would result from a given contraction of a shell of steel, say 30 miles thick, acting on a sphere of the size and composition of our earth.[1] A theory is of little use without a quantitative basis. When this is worked out it may be found unnecessary to calculate the amount of compression of the interior which a local shrinkage of a given segment of the sphere would be competent to produce, if, indeed, it would produce any, which I very much doubt.

[1] If we look upon this shell as a spherical boiler of steel 30 miles thick and of the diameter of the Earth, dependent only upon its tensile strength, a pressure of steam of half a ton to the square inch would burst it. It is questionable if such a shell of steel could by shrinkage exert an effective pressure of one quarter of a ton per square inch on the materials of the interior of the Globe.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Sixty-fourth Annual Meeting, held at Oxford, August 9th to 14th, 1894.

List of Papers read in Section (C), Geology.

L. Fletcher, M.A., F.R.S., F.G.S., President.

The President's Address.

Prof. A. H. Green.—Some Points of Special Interest in the Geology of the Neighbourhood of Oxford.

E. A. Walford.—Report of the Committee on the Stonesfield "Slate."

E. A. Walford.—On the Terraced Hill Slopes of North Oxfordshire.

Prof. W. Boyd-Dawkins.—The Probable Range of the Coal-measures under the Newer Rocks of Oxfordshire and the Adjoining Counties.

Prof. W. Boyd-Dawkins.—On a Deposit of Iron Ore in the Boring at Shakespeare's Cliff, Dover.

J. Logan-Lobley.—On the Cause of Earthquakes.

Dr. Tempest Anderson.—On certain Volcanic Subsidences in the North of Iceland.

Joint Discussion with Section H, on the Plateau Gravels, opened by Mr. Whitaker and Prof. T. Rupert Jones.

Sir Archibald Geikie.—On some Traces of Two Rivers of Tertiary Time in the Inner Hebrides.

H. A. Miers.—On a New Method of Measuring Crystals, and its Application to the Measurement of the Octahedral Angles of Potash-Alum and Ammonia-Alum.

Prof. T. G. Bonney.—A Comparison of the Pebbles in the Trias of Budleigh Salterton and of Cannock Chase.

Howard Fox.—On a Soda-felspar Rock at Dinas Head, North Coast of Cornwall.

O. W. Jeffs.—Report of the Committee on Geological Photographs.

Prof. T. R. Jones.—Report of the Committee on Palæozoic Phyllopoda.

M. Laurie.—Report of the Committee on the Eurypterid-bearing Deposits of the Pentlands.

Dr. R. H. Traquair.—Preliminary Note on a New Fossil Fish from the Upper Old Red Sandstone of Elginshire.

Dr. H. Hicks.—The Homes and Migrations of the Earliest Known Forms of Animal Life, as Indicated by Recent Researches.

Montagu Browne.—On some Vertebrate Remains from the Rhætic of Britain (Third Contribution).

Osmund W. Jeffs.—On some Forms of Saurian Footprints from the Cheshire Trias.

P. F. Kendall.—Report of the Committee on Erratic Blocks.

Dugald Bell.—Report of the Committee on the High-level Shell-bearing Deposits of Clava, etc.

Dr. H. Hicks.—On some Lacustrine Deposits of the Glacial Period in Middlesex.

Prof. J. F. Blake.—Sporadic Glaciation in the Harlech Mountains.

Prof. T. G. Bonney.—On the Probable Temperature of the Glacial Period.

E. P. Culverwell.—An Examination of Croll's and Ball's Theory of Ice Ages and Genial Ages.

Prof. J. F. Blake.—On the Mechanics of an Ice Sheet.

Rev. E. Jones.—Report of the Committee on the Elbolton Cave.

Rev. E. Jones.—Report of the Committee on the Calf Hole Cave.

Prof. W. Boyd-Dawkins.—On the Permian Strata of the North of the Isle of Man.

Prof. W. Boyd-Dawkins.—The Carboniferous Limestone, Triassic Sandstone, and Salt-bearing Marls of the North of the Isle of Man.

Sir Henry Howorth.—Strictures on the Current Method of Geological Classification and Nomenclature, with Proposals for its Revision.

Montgomerie Bell.—The Pleistocene Gravel at Wolvercote, Oxford.

R. Bruce Foote.—Prehistoric Man in the Old Alluvium of the Sabar Mati River in Guzerat.

Prof. W. A. Herdman.—Report of Committee on the Marine Zoology of the Irish Sea.

C. Davison.—Report of the Committee on Earth Tremors.

Dr. H. J. Johnston-Lavis.—Report of the Committee on the Volcanic Phenomena of Vesuvius.

Prof. W. J. Sollas.—Report of the Committee on the Investigation of a Coral Reef.

Prof. W. Hennessy.—On the Shape of the Banks of Small Channels in Tidal Estuaries.

C. E. de Rance.—Report of the Committee on Underground Waters.

W. W. Watts.—On a Keuper Sandstone cemented by Barium Sulphate, from the Peakstones Rock, Alton, Staffordshire.

Titles of Papers bearing on Geology, read in other Sections:—

J. W. Thomas.—On the Chemistry of Coal Formation.

T. Johnson.—Chalk-forming and Chalk-destroying Algæ.

Prof. Osborn.—On Certain Principles of Progressively Adaptive Variation observed in Fossil Species.

W. P. Pycraft.—The wing of *Archæopteryx* viewed in the light of that of some Modern Birds.

Dr. Scott.—The Structure of Fossil Plants in its bearing on Modern Botanical Questions.

A. C. Seward.—A Contribution to the Geological History of Cycads.

H. Stopes.—The Evolution of Stone Implements.

II.—On the Geology of the Plateau Implements in Kent. By Professor T. Rupert Jones, F.R.S., F.G.S.[1]

THIS subject having been fully treated of by Prof. J. Prestwich, the requisite references to his various memoirs elucidating the general geology of the local drift-deposits, the geological stages of their formation, and the peculiar flint-implements of the plateau are given. He has shown that certain superficial soils on the North Downs between Sevenoaks and Rochester contain numerous rudely worked flints, discovered by Mr. B. Harrison; and that these were derived from a gravel, of very great antiquity, originally formed on

[1] Read before Sections C and H, British Association, Oxford.

the side of the old Wealden Hill-range or mountain, which once rose about 3000 feet above where Crowborough and other hills in Sussex now are. Man existed at the time of these gravels, and used the flints for tools. These gravels and the implements left in them were removed by natural agencies, such as rain, rivers, sea, frost, and ice, and distributed by torrential streams on the Chalk slopes (now part of the North Downs) at a lower level on the flanks of the range.

These rude old flint implements have an ochreous colouring, due to ferruginous gravel, whence they came; and are now found on the plateau, sometimes with limited patches of some of the ochreous flint gravel, together with Tertiary pebbles, less-worn flints, and fragments of Lower Greensand, on the red "clay-with-flints" covering the Chalk. It is shown how desirable systematic excavations, to prove the extent and thickness of the implementiferous soil, would be.

Prof. Prestwich's history of the origin of the ancient Wealden Dome, Island, and Hill-ranges, and of the gradual destruction of those uplands, in the course of untold ages, with the resulting formation and removal of successive geological groups of strata, such as the Thanet Sands, Woolwich and Reading Beds, London Clay, Lenham Beds, and the old ferruginous gravel with its rude implements above mentioned, are noticed in detail.

The Diestian or Lenham Beds were found in the Early Pliocene period; and the denudation of Holmesdale probably began directly afterwards, at about the time of the Red or the Chillesford Crag in Late Pliocene, or in post-Pliocene times; and the old ferruginous gravel had not only been formed, but washed away to a lower level before that time.

The ultimate denudation of the valley cutting off the Chalk from the Weald being subsequent to the formation and removal of that gravel, the latter must have been pre-Glacial in age.

REVIEWS.

I.—(1) Les preuves de l'Existence d'Organismes dans le Terrain Pré-Cambrien, première note sur les Radiolaires Pré-Cambriens. Par M. L. Cayeux. Bulletin de la Société Géologique de France, 3e s., tome xxii. pp. 197–228, pl. xi., année 1894.

(2) Sur la présence de restes de Foraminifères dans les Terrains Pré-Cambriens de Bretagne. Note de M. L. Cayeux, présentée par M. Fouqué. Comptes Rendus de l'Académie des Sciences. Tome cxviii. No. 25 (18 Juin, 1894), pp. 1433–1435.

(1) Proofs of the existence of Radiolarians in Pre-Cambrian rocks. By M. L. Cayeux.
(2) Remains of Foraminifera in the Pre-Cambrian of Brittany. By M. L. Cayeux.

ABOUT two years since Dr. Charles Barrois announced, in a brief note to the "Comptes Rendus," the discovery of Radiolaria in Pre-Cambrian rocks of the horizon of the mineral schists and phyllites of St. Lô, in the north of Brittany. The further description

of these, probably the oldest fossils known, was intrusted to M. L. Cayeux, who has had considerable experience in the study of Radiolaria and other microscopic organisms in the Cretaceous rocks; and the first of the above papers contains the results of a careful investigation into the nature of these bodies from an examination of numerous sections of the rocks in which they are preserved.

From the geological sections of the country drawn up by Dr. Barrois no doubt can be felt as to the horizon of the fossiliferous beds, which are bands of phtanite from half-an-inch to over three feet in thickness, interstratified with the schists. The phtanites are now principally of crystalline silica, and a certain amount of carbonaceous material is also present in them.

The bodies described as Radiolaria are irregularly distributed in the phtanites, sometimes occurring singly, at others great numbers are closely associated together, so as occasionally to be in actual contact. They are exceedingly small in size—the figured forms range from ·001 mm. to ·022 mm. in diameter—and to observe their structures it is needful to use much higher object-glasses than those required for other fossil and recent Radiolaria. By far the larger number are simply spherical in form, some are ellipsoidal, and there are many varieties of the inflated or cyrtoidal bell-shaped forms. One or more radial spines occur in several forms, and in two or three an inner concentric shell connected by rays with the outer test has been detected. Most of the forms figured have holes or perforations in the outer test, thus showing a lattice-like structure. This is considered by the author to be present in all, though not always recognisable.

The author has figured 45 different forms of these minute bodies, and the greater number are assigned to different known Radiolarian genera, 19 in all; a few forms cannot be placed in any described genus, but all are comprised in four of the great subordinal divisions of Haeckel, viz., Sphæroidea, Prunoidea, Discoidea, and Cyrtoidea. The author thus confidently asserts the close relationship of these Pre-Cambrian forms to existing and other fossil Radiolaria.

It will readily be conceded that, at a first glance, the forms which the author has had figured on the accompanying plate by an artist unacquainted with these organisms (and therefore unbiassed) present a strong *primâ facie* resemblance to known Radiolaria. Certain objections have, however, been made to placing them in this group by some who have had the opportunity of seeing sections of the rock containing them, and the author has very fairly and candidly stated these objections and replied to them in the paper. It should, perhaps, be mentioned that the figures now given have been taken from specimens lately obtained by the author, which show their characters more distinctly than in those which came under the notice of the objectors.

One objection is based on the extremely small size of the Pre-Cambrian bodies as compared with the dimensions of undoubted Radiolaria. This difference is very striking under the microscope, and it may be expressed by the fact that the average diameter of the

44 figured forms of which the dimensions are given is ·0115 mm; whilst the average diameter of 44 of the Palæozoic Radiolaria figured by Dr. Rüst (taking the 44 species first described) is ·2 mm.; thus it would require the combined diameters of 17 of the Pre-Cambrian bodies to reach the average diameter of one of the Palæozoic Radiolaria. The author considers that the small dimensions of the ancient forms may possibly arise from different biological conditions, and, that as size does not enter into the diagnosis of recent Radiolaria, the objection is not valid in the present case. It may, however, be noted that there is no important difference in the size of existing Radiolaria and that of fossil forms as far down as the Silurian and Ordovician rocks, and there is, therefore, no ground for anticipating that still earlier forms would be more diminutive than those of Ordovician and later times. Other objections are based on the fact that it is only in some of these bodies that perforations can be discovered, whilst it is also stated that they are too regularly spherical to be Radiolaria, and further that the bodies are not organic but are produced by the juxtaposition of small rounded granules, and that the interstices between these give the appearance of perforations. The author considers that such an interpretation is inconsistent with the law of optics, and that the perforations are really pores in the siliceous test.

Dr. Rüst, judging from the section supplied to him by the author, considered that the small rounded bodies more nearly resembled the detached chambers of Foraminifera than Radiolaria, thus allowing the organic character of the forms present; but this view does not account for the larger perforations in the test of some, and further will not apply to those which are bell-shaped. The author has, however, since the publication of the first paper, communicated a note to the "Comptes Rendus," in which he asserts the Foraminiferal character of some of the bodies in the Pre-Cambrian phtanites associated together with the forms described as Radiolaria. Of these Foraminifera, both simple and compound forms are present, but the simple specimens are hardly to be distinguished from those Radiolaria in which the pores are obliterated. The compound forms consist of a variable number—ranging from 2 to 7—of spherical or ovoid chambers of different sizes aggregated together. In some cases the chambers are furnished with one or more short blunted spines. The walls are very finely perforate, and they are therefore included in the perforate group of Carpenter. In size they correspond with the Radiolarian bodies; the largest of the chambers hardly reaching the diameter of 10 micromillimetres(=·01 mm. or about $\frac{1}{2500}$ of an inch), and thus the objection made to the Radiolarian bodies on account of the disparity in size in comparison with recent forms will equally apply to these Foraminifera.

The importance of determining the real character of the minute bodies in these Pre-Cambrian rocks will be generally recognised, and we cordially trust the author will persevere in his researches until he meets with evidence sufficient to convince those who now feel some hesitation in accepting his conclusions about them.

G. J. H.

II.—1. Western Australia in 1893. By Francis Hart. Illustrated by Maps of the Colony and numerous Photogravures and Sketches. Published by authority of the Government of Western Australia (1893). London: 8vo. pp. 276. Issued in 1894.

2. Western Australian Year-Book for 1892–93 (seventh year of issue). By Malcolm A. C. Fraser, Registrar-General. By authority, pp. i.–viii. and 1–276, with a Map of the Colony. (Perth, 1893.)

3. Mining Hand-Book to the Colony of Western Australia, written expressly for Prospectors and Strangers to the Colony who are interested in Mining. By Harry P. Woodward, F.G.S., F.R.G.S., F.I.Inst., Government Geologist. By authority of the Commissioner of Crown Lands. 8vo. pp. 126, illustrated with numerous Maps, etc. (Perth, 1894.)

4. Geological Sketch-Map of Western Australia, 1894. Scale of Nature 1 : 3,000,000. By Harry P. Woodward, F.G.S., F.R.G.S., F.I.Inst., Government Geologist, Perth. Size of Map 2 feet × 3 feet. (Published by George Phillip and Son, 32, Fleet Street, London, E.C.)

WE have frequently called attention to this rapidly-advancing colony in the pages of the Geological Magazine, and many of its fossils have been described and figured in its pages.[1]

This year has been more than usually prolific in publications issued by authority of the Government of Western Australia, and none need henceforth complain of being kept in ignorance of the wonderful discoveries as to its mineral resources, which have so astonished the world during the past few years.

Mr. Hart's Handbook is now in its second edition, and is what it professes to be, an excellent compilation from official and other reliable sources, of all matters of interest, whether political, mining, or agricultural, relating to the colony of Western Australia.

In extent of territory it greatly exceeds all the other Australian colonies; and only a short time since it was seriously proposed to subdivide it, but for the present it remains intact, with a length of 1400 miles from north to south, 1000 from east to west, and a coast-line of more than 3000 miles. Nevertheless, with all its natural advantages of climate and geographical extent, it has until the present the smallest population of any colony on that continent; but the author believes that population by means of emigration can only be obtained in competition with other countries, by offering some stronger attraction to the emigrant, as did the great gold discoveries in Victoria in 1851. Such a magnetic attraction is now

[1] Geol. Mag. Dec. III. Vol. III. 1886, pp. 1–7, Pl. I.; Geol. Mag. 1889, p. 432. *Ibid.* 1890, pp. 97, 98–106, Pls. IV. and V.; pp. 145–155, Pls. VI. and VII.; pp. 193–204, Pls. VIII. and VIII.A; pp. 481–492, Pls. XIII. and XIV. *Ibid.* 1892, pp. 132, 133; pp. 433–437, Pl. XII.; pp. 468, 469, 542–544, Pl. XIV. *Ibid.* 1893, p. 288; pp. 412, 413. *Ibid.* 1894, pp. 385–393 *et seq.*, Pls. XII. and XIII.

being exerted by Western Australia, whose gold-fields seem likely to surpass in richness those of any other part of the world.

It remains to be seen whether the thirst for growing rich rapidly, will influence a larger body of adventurers to try their fortunes in this colony than have already been drawn to her shores; certainly opportunities are not lacking to those who can seize upon them at the right moment.

It is quite evident that Western Australia will always rank as a mining colony. The report of gold recorded by the Customs in 1892 amounted to 59,548 ounces, which at £3 16*s.* per ounce would realize £226,283; being an increase of £111,101 over the year 1891. This gold was obtained as follows, viz.:—

	£	*s.*	*d.*
Customs-returns of gold from near Albany	901	13	8
,, ,, from Yilgarn...	79,694	7	4
,, ,, ,, Cossack...	48,992	12	9
,, ,, ,, Wyndham	2,683	9	7
,, ,, ,, Derby	680	15	4
,, ,, ,, Ashburton	2	13	2
,, ,, ,, Murchison	27,110	12	0
,, ,, ,, Kimberley	773	7	3
,, ,, ,, Champion Bay ...	65,444	0	0
	£226,283	11	1

Much gold, however, was obtained which was never declared to the Customs.

No better sign of vitality in this colony, which has quite lately obtained its Constitution, can be instanced than the fact of its providing a sum of £71,482 for public works and buildings; this includes the erection of many school-houses and the expenditure of £2000 for the building of a Museum in Perth.

In his summary of the Geology, Mines, and Minerals of the colony, the author (Mr. Francis Hart) has, by an error, described Mr. H. Y. L. Brown, F.G.S., as the "*late* Government Geologist of S. Australia, and *now employed* by the N. S. Wales Government" (p. 57), and he repeats this error at p. 69. We are happy to state that Mr. H. Y. L. Brown, F.G.S., is *not late*, but is still, *the* Government Geologist for S. Australia; long may he continue to occupy that post to the advantage of the colony of South Australia!

2. This is the seventh annual issue of the "Western Australian Year-Book," 1892–93, by Malcolm A. C. Fraser, Registrar-General. A most useful book, which gives in a brief summary the discovery of Western Australia, its colonization and early settlement, its constitution and government. Much valuable information is also collected bearing upon its mineral, pastoral, agricultural, and forest resources, its population, health, and climate.

The forests, from which timber for export is obtained, are situated within the parallels of South latitude 31° to 35° and extend over an area of about 30,000 square miles, or equal to the whole territory of Scotland. Over this vast extent of wooded country a species of *Eucalyptus* (the Jarrah) prevails, which for the durability of its timber is unsurpassed by any kind of tree in any portion of the globe.

This tract is within a moderate distance of the coast, thus rendering its productions easily accessible for shipment to foreign ports.

Stems of these giant trees have been measured 80 feet to the first branch, with a circumference of 32 feet at 5 feet from the ground, while the maximum height of the Jarrah is certainly not over estimated at 400 feet.

The entire acreage of the colony is estimated at 624,588,800 acres; of this area not more that 161,459 acres were under cultivation in 1892. This is not surprising when we find the population in this vast area, at its highest, recorded at 60,000,[1] the larger proportion of whom is engaged in mining, in the timber trade, and upon the construction of railways in the colony, or living in towns and occupied in commerce.

The Constitution under which Western Australia is now governed was granted on the 15th August, 1890, and the present Ministry assumed office on the 29th December, 1890, so that, for a "four-year-old" government that of Sir John Forrest deserves the highest praise for the work it has accomplished in so brief a period of its existence.

3. "The Mining Hand-Book," by Harry P. Woodward, F.G.S., the Government Geologist, deserves notice as a most laudable effort to supply the requirements and answer the questions of a vast number of people who "*want to know*," and insist upon having official information, on the geography, geology, and mineral resources of the colony generally. The author tells us he has not written it as a scientific treatise, but has tried, as far as possible, to give the information required in as simple a form as possible, so as to bring it within the understanding of persons who have had no scientific training. After a general description of the physical and geographical features of the colony, its water-supply, timber, etc., Mr. Woodward deals with the geognosy of each district in detail, commencing with the Kimberley District in the north; then the North-Western District, followed by the Gascoyne District, which is succeeded by the Victoria; the South-Western District, the Plantagenet and the Eastern District.

The author then proceeds briefly to sketch the geology. He points out that the earlier notion regarding this continent, which assumed it to possess only a very limited number of formations, was erroneous, and that every formation known in other parts of the world is represented here, from the most ancient Archæan rocks with Cambrian, Silurian, Devonian, and Carboniferous, attested by the evidence of the fossils they contain, which have been figured and described by Mr. Wilfrid Hudleston, F.R.S. (see Quart. Journ. Geol. Soc. 1883, vol. xxxix. p. 582, pl. xxiii.), by Dr. G. J. Hinde, V.P.G.S., Dr. H. Woodward, P.G.S., Mr. A. H. Foord, F.G.S., and Mr. R. B. Newton, F.G.S., in the pages of this MAGAZINE from 1886 to 1894, whilst the Jurassic, Cretaceous, and Tertiary formations have also been certified by their organic remains, described

[1] Sir Malcolm Fraser, on 15 August, 1894, gives it at 71,000 on 31 March last, and 86,000 on 30 June, 1894, an increase due to the steady influx of mining prospectors now taking place, especially in the south.

by the late Mr. Charles Moore, F.G.S., by Dr. J. W. Gregory, F.G.S., and Mr. G. C. Crick, F.G.S.

The author describes briefly the aspect of mineral veins, and gives four illustrations of their appearance. He then devotes two pages and two diagrams in order to explain why, in certain areas, spring water may be obtained by boring, whilst in others it is hopeless to expect to obtain an artesian supply of water. The area occupied by each formation is then briefly noticed.

This is followed (pp. 34–55) by a short description of the minerals of commercial value which have been found, or are likely to be met with, in the colony, and the common tests by which such minerals may be recognised.

The metallic minerals are first described, and then the non-metallic; and under each is given their occurrence and uses. To this follows the account of the gold-fields of the colony (pp. 56–78). The return given by the Customs of the export of gold in the last seven years shows a value of £952,182, rising from £1,207 in 1886 to £421,385 in 1893.

This return is only the amount *declared* at the Customs, and is far below the actual export, which cannot be correctly ascertained. Most old miners are silent as to their actual gains.

The author then gives a description of other mineral deposits, as Copper-Lead, Copper, Tin, Coal, Iron and Antimony, Zinc, Manganese Graphite, etc. Much general information follows as to the means of reaching the various gold-fields, and the necessary outfit; licenses to mine; means of shipping; a glossary of terms in use by miners, etc.

No one need complain of the quantity of information contained in this little work of 126 pages, which is certain to prove of great service to the many whom it is intended to assist.

4. It must require a man as courageous as the "Bold Buccleuch" to undertake the post of Government Geologist for Western Australia, and to map an area of 976,000 square miles, being about nine times the size of the United Kingdom. We can well understand Mr. H. P. Woodward when he writes that since 1887 (a period of seven years) he has spent most of his time in travelling about this vast territory, and in examining and reporting upon the mineral resources of the colony generally.

Prior to Mr. Woodward's appointment in 1887, small portions of the colony had been examined between the years 1847 and 1851, by Dr. F. von Sommer; and prior to 1860, by Messrs. A. C. and F. T. Gregory (who published a geological map, in London, of a part of the colony in 1860). Mr. Hy. Y. Lyell Brown, F.G.S., made a geological examination of a part of the colony in 1870–71, mapping a strip of country from the Murchison River to the south coast. In 1882 Mr. E. T. Hardman reported on the Kimberley District, and indicated the existence of extensive gold areas in the north-west, which have since yielded a considerable amount of the precious metal.

The Map which the Government Geologist has just completed, and which has been carefully engraved and reproduced in chromo-

lithography by Messrs. George Philip and Son, embodies not only the work of those earlier geologists, to whose labours we have briefly referred above, but gives a vast amount of information derived from careful geological field-work, which Mr. Woodward has accomplished during numerous expeditions, extending over the past seven years.

The largest additional areas coloured geologically extend from north of Pilbarra (lat. 20° South) to the Murchison; and the great area enclosing the Wyndham and Kimberley gold-fields in the extreme north-eastern territory, and the region about Albany, and towards Eucla in the south.

Taking the whole area of the colony at 976,000 square miles, about one-half of this has now been *provisionally* surveyed and geologically coloured on the Map. The major part of this explored area extends along the coast, and may be said to comprise a belt about 250 to 300 miles broad, reaching from Condon, north of Pilbarra, down to Cape Howe in the south, a stretch of country rather over 1000 miles in length. A second and minor area is that of the Kimberley Division in the extreme north-east of the colony, also geologically coloured on the present Map, embracing an area of probably not less than 67,000 square miles. The former and major area may be roughly divided into a broad belt 100 miles in width, and 600 in length, of volcanic rocks (granite and basalt), flanked on the west by a band, 50 to 100 miles broad, of crystalline schists and granite, and on the east by a belt of metamorphic rocks, clay slates, quartzites, etc., in which the principal gold-fields are situated. These highly altered rocks also extend for some 300 miles along the coast to the east of Albany, being covered inland by sands, limestones, and clays of Tertiary age, which stretch for 600 miles eastwards to Eucla, and 200 miles inland to the northward towards the Dundas and Coolgardie gold-fields.

At Fly Brook, and on the Collie River, Coal-beds, believed to be of Carboniferous age (but possibly younger), occur; and again on the Irwin, and probably on the Murchison also.

From here rocks of Carboniferous age, usually fossiliferous, extend in a northerly direction, about 50 miles from the coast, in a belt 20 miles wide, and covering a still larger area to the north-east, and again making their appearance on the south side of the Kimberley gold-field, and outcropping along the edge of the basalt flow, between Mt. Elder and the Antrim Plateau. Notwithstanding the larger area over which these formations are known to extend, very few beds of the series are exposed, being but little disturbed or faulted, and lying nearly always in a horizontal position.

In the Ashburton, Pilbarra, and Kimberley Districts, Cambrian, Silurian, and Devonian rocks occur, especially in the higher ranges.

The Stirling range, to the north of Albany, is probably also of Silurian age. Chalky limestones with flints forming the Lower Cretaceous beds occur at Gingin, 50 miles to the north of Fremantle, and extend for 600 miles, more or less, uninterruptedly to Onslow, on the Ashburton River. To the Cretaceous age is also attributed

the overlying ferruginous sandstones, conglomerates, and clays, which not only form the flat-topped coast range, but stretch away far into the interior, forming the large table-lands, and capping the ranges to the eastward. This formation is probably an extension westwards of "the great desert sandstone" formation of the Eastern Colonies. No fossils have been found in these rocks, but as they rest conformably upon true Cretaceous rocks, both here and in South Australia, they have been classed with them; but it is quite possible they may be of *much later age*. These Cretaceous rocks are underlain by strata of Jurassic age to the north of Champion Bay, from which fossils have been obtained and described by the late Mr. Charles Moore, F.G.S., and also by Mr. G. C. Crick, F.G.S. (in this present number of the GEOLOGICAL MAGAZINE).

Although highly important to the agriculturist, the Tertiary deposits of the colony do not appear, geologically speaking, to be of considerable interest. The largest area, coloured as Cainozoic, is that of the Eucla division. The Coralline limestones form the lower beds of the coast, and are well seen at Shark's Bay and on the islands adjacent. These limestones contain many fossils, and are said to be of Eocene age. The sand-plains (of Pliocene age) are a characteristic feature of Western Australia, extending in places from one end of the colony to the other. The great sand-plains of the interior are not unfrequently 20 to 30 miles across, but as they usually contain a good deal of clay and iron which cement the grains of sand together, and there being a fair rainfall, they are covered with a hardy vegetation, and during the two spring months they are perfectly gorgeous with flowers, and form good summer grazing-grounds. These sands result mostly from the disintegration of the great desert sandstone, which forms the table-land of much of the interior of Australia.

Add to these the Shelly Limestones of the coast; the Estuarine and River-valley deposits; the Raised beaches; the ancient River-gravels and Lake-basins; and we have a very fair notion of the nature of the later deposits of this colony. In addition to the coal-fields, which are indicated by black oblique lines, the author shows on the map by similar means, in various colours, the tin-fields; the lead, copper, and last, but by no means least, the vast extent of the gold-fields of this wonderful colony, which has lain dormant so long waiting for the master-mind which should develop it, or, rather, which should re-act upon other minds, and so stimulate its fellow-men to go forth to colonize this hitherto all but *terra incognita*, where fortune awaits the man of enterprise. With such a Map to aid one; with such guide-books to direct one's steps; with so admirable an Agent-General here in London as Sir Malcolm Fraser to assist one; with so energetic a Premier as Sir John Forrest out in Perth; and so able a Government Geologist as Mr. Harry Page Woodward, to advise them on the spot, what need the emigrant fear who embarks for Western Australia? The climate is the finest in the world, and the death-rate the lowest.

III.—Proceedings of the Malacological Society of London. Vol. I., October, 1893—June, 1894. 8vo. pp. 138, 10 Plates. (London: Dulau & Co.)

THE first three numbers of the Proceedings of this vigorous young Society, whose President is Dr. Henry Woodward, F.R.S., lie before us, and if they be any earnest of the future of the Society, which may be said to show its hand in them, they indicate that, if cheiromancy be worth anything, assuredly the Society's "line of life" will be long. The object of this new bond between malacologists, we learn, is "to facilitate the study of the Mollusca and Brachiopoda, both recent and fossil," and we are pleased to note that the palæontological side of the subject is fairly represented by some most valuable and important papers by Mr. G. F. Harris and Mr. R. B. Newton, who in three out of their four contributions write conjointly. Their "Revision of British Eocene Scaphopoda" and "Revision of British Eocene Cephalopoda" are memoirs that will long be of great value, even in these days of rapidly increasing knowledge. In the latter paper Edwards' anomalous genus *Belemnosis* is neatly disposed of; for, acting on a hint received from Mr. F. A. Bather, the authors are able to show that it was founded on a rolled specimen of *Spirulirostra*. Their paper on some little known Pulmonate Mollusca from the Oligocene and Eocene formations of England, is, we think, less happy; the authors having given living force to certain MS. names, some of which, considering the very fragmentary nature of the specimens, had better have been left in obscurity; nor do they seem yet to have realized that *Planorbis* has long been known to be a sinistral, not a dextral, genus. It is to be hoped that further contributions from these and other palæontologists may be found in future numbers of the Society's Proceedings.

IV.—Creatures of Other Days. By Rev. H. N. Hutchinson, B.A., F.G.S. With numerous Illustrations by J. Smidt and others (24 plates and full-page illustrations, and 79 illustrations in the text). Pages xv. and 270, 8vo. Chapman & Hall, London, 1894.

MR. HUTCHINSON'S former book, "On Extinct Monsters," noticed in the Geol. Mag. for January, 1893, was a praiseworthy and successful attempt to give a good popular account of many of the more noteworthy denizens of this world existing before the advent of Man, and now known only by their fossilized bones, teeth, and scales. Some of these relics, formerly gazed at with ignorant wonder, and often referred to as evidences of prehistoric giants drowned by the Noachian Deluge, had gradually during the last century been pieced together into intelligible forms, though strange even to those who knew something of the various modifications of the animals now existing. Limited groups of such reconstructed skeletons have been frequently used in Manuals and Text-books of Geology, and were occasionally invested with imaginary

integuments. These creatures in some instances were, as far as circumstances permitted, even represented by solid models, such as Mr. B. Waterhouse Hawkins made of the little *Dendrerpeton* and of the gigantic forms still visible in the gardens of the Crystal Palace.

The advancing science of palæontology, realizing more and more of the fossil remains of vertebrate animals, as discoveries have been made of late years, especially in the North-west Territories of the United States, has rehabilitated many of the former creatures of all the continental lands, whether they had been washed out to sea, drowned in lakes, swamped in bogs, or left in rifts and caverns of the solid rocks. Several of these were boldly figured in their living aspects, and vividly described for the general reader, in Mr. Hutchinson's former volume, and its second edition, including some very old and interesting forms, quaint indeed, and strange among their modern successors and representatives. Not excepting even those who know by close study something of the numerous links of the wonderful chain of life, all must be astonished at the manifold and ever-varying representatives of the corporeal types that present themselves once more when the dry bones seem to live again in the studio or museum, taking their relative places among, or near to, the several kinds of existing animals. Doubtless many links, still missing, will be supplied by either personal or national well-directed research.

How many such fossils have been found and cared for by societies and persons at home and abroad, the several large Museums about the world plainly show. Not least, the Natural-History Branch of the British Museum; and of this Mr. Hutchinson has especially availed himself in enlarging his menagerie of extinct animals in the very presentable volume before us.

Our friends in the United States have obtained vast collections of teeth, bones, and skeletons, not merely with expense and trouble, but often with personal danger to explorer and collector in the North-western Territories. The talented and hard-working palæontologists have described and figured the remarkable animals restored from these bones; and, years ago, they had life-sized models made of some, by the late Mr. B. Waterhouse Hawkins, for the Central Park of New York. In preparing, for the Educational Department, these bodily restorations of early and long-past creatures, which exact knowledge proves to have had near relationship with existing forms, and in themselves to be "manifestations of the present and all-pervading plan," Mr. Hawkins must have been highly "gratified in advancing the means of educational progress in America" (Geol Mag. December, 1879). An ignorant Mayor of New York City, however, being told that the restorations represented *extinct* creatures, said that, if the Creator had ordained their extinction, they should be extinct; and this great magistrate of a great city had the models extinguished by sledge-hammer and burial. But still God's creatures survive in appreciable fossils, and by books and illustrations, to the advantage of science, and hence, in many ways,

to the welfare of intellectual communities; and fanatical ignorance has only damaged the credit of its votaries. Figures of the restored *Hadrosaurus* and *Dryptosaurus* (*Lælaps*) are reproduced in Chap. vii. in two plates from the Central Park Reports for 1869–70; that of *Hadrosaurus* is also given at page 488 of J. La Conte's "Elements of Geology," 1886.

Still more strongly may it be said of Mr. Hutchinson's work (in presenting to the general public so many exemplifications of animal variety resulting from the fixed and inexplicable laws of life in successive ages, long before Man's appearance on Earth), that he not only opens up for many, unthought-of scenes with strange actors, but strengthens the intellectual growth of the rising generation; for, the more that is known of the Earth and its history, the broader and better is popular knowledge in general, and the more exact and aptly useful is professional knowledge.

The accepted series of Geological Formations characteristic of the several periods, when Invertebrates, Fishes, Reptiles, Mammals, and Man have been successively abundant or dominant, is given in the Appendix i. A classification of Vertebrate Animals, in Appendix ii., shows how the many kinds, both existing and extinct, fall into order, according to their known structure, and form correlative groups, linking fishes, at the lowest end of the scale, to Man at the highest. With these plans or synopses of nature before him, the reader can better grasp the meaning of the author's arrangement of his subject, and the details given in his twelve chapters.

The markings left on mud-flats and other soft surfaces by various burrowing, trailing, crawling, and walking animals are referred to as "footprints on the sands of time," in Chap. i.; those made by four-footed animals being chiefly noticed. The Fishes, as the lowest of the back-boned animals, come in Chap. ii., with notes as to their evidence of the "law of progress." As in all the other chapters, the author makes careful allusion to those who have collected, recorded, and elucidated the fossils.

The Batrachian and other Amphibia of the present day are the tropical Cœcilians, Illyrian Proteus, American Siren, Axolotl, and Menobranchus, Javanese Menopoma, European Newts, and world-wide Frogs and Toads. Of these the Frog group is represented in the Tertiary formations only; but, as Chap. iii. fully shows, there were very numerous creatures more or less allied to such Salamanders as *Menopoma* and its allies in foregone periods of the Earth's history, when the Carboniferous, Permian, and Triassic beds were being formed. Of these the *Archægosaurus* and *Labyrinthodon* are frequently mentioned. Their sculptured skull-bones and dermal plates, their teeth with internal labyrinthic structure, and their peculiar skeletal bones, are very characteristic, sometimes giving a salamandroid, and sometimes an elongate fish-like shape. The different size of the well-known Triassic prints of the fore and hind feet at first suggested a somewhat frog-like, shambling body (Owen); and as such it appeared in various text-books in 1850–60. During that period it had taken the more toad-like position in

the model by Mr. B. W. Hawkins,[1] alluded to at pages 57 and 144. Prof. Owen's outline of the creature was grossly exaggerated into an awkward sprawling attitude in some manuals of geology about 1865. We have still to be thankful for Owen's suggestive sketch of such an animal as could have left the Cheirotherian foot-prints; especially since nothing in Chapters iii. and iv. explains their incongruous appearance. The *Actinodon*, however, in Plate III. makes some approach to the conditions required. A special point of interest with regard to these old fossils is that they supply links between fish and reptile. Ireland and Bohemia have more especially supplied several well-preserved Labyrinthodont Amphibia, chiefly from the Coal-measures.

The great Ichthyosaurian tyrants of the Triassic, Jurassic, and Cretaceous seas had relationship to both fishes and lizards; and Chapter iv., headed "Anomalous Reptiles," treats of some extinct creatures allied to the Amphibia and the Sauria or "Reptiles proper,"—such as the *Dicynodon*, *Oudenodon*, *Tapinocephalus*, *Galæsaurus*, and especially the great *Pareiasaurus*, all from the Karoo formation of South Africa. Moreover, some of these peculiar South-African reptiles possess indications of having affinity to the mammals succeeding them.

The earliest Lizard (or true Reptile) known is the Permian *Proterosaurus*; the Triassic *Rhynchosaurus* and *Telerpeton* come next. The wonderful *Elginia mirabilis*, with its diabolically horned and prickly skull, coming (like the last-mentioned) from the Trias of Scotland, is said to be related to both labyrinthodonts and lizards.

The Crocodiles come next in order of animal structure; and Chap. v. gives a sketch of their history. The earliest were in the Trias (the first formation in the Mesozoic, or middle-life, period); and animals of the same type have survived (that is, have been successively represented) until now, "with comparatively little change either in structure or habits," being "one of Nature's persistent types"; but the sharks, nautiloid and nuculoid molluscs, some brachiopods, bivalved crustaceans, and rhizopods have held on for a much longer time,—even from the Silurian period. The land and water conditions formerly existing in the European area favourable for crocodilian life, and the remarkably abundant co-existence of crocodile, gavial, and alligator in what is now part of the British area, have been fully described with the poetry of simple truth by the late Professor Owen, and quoted by Mr. Hutchinson at pages 115 and 116.

In Chapters vi. and vii. are described several of the extinct Reptiles which have usually a long neck, big body, strong hind legs, and powerful tail, but always short front legs and relatively small head. From the dreadful aspect which our *Iguanodon*, *Hylæosaurus*, and *Megalosaurus* were supposed to have had, these creatures were named Dinosaurs (or Deinosaurs=terrible-lizards). Of late years their forms have been better understood; and, indeed, there have been many newly discovered examples showing "the

[1] Mr. Hawkins's sketch of the Crystal Palace Models was published in the "Journal of the Society of Arts," No. 78, 1854.

definite shapes and proportions of some of the great and long-unknown reptilian masters of the world, whether dignified in their monstrous bulk and unused power, as Herbivores, or domineering as the Carnivorous tyrants of their day" (GEOL. MAG. 1869, p. 566).

Hypsilophodon, *Compsognathus*, and *Hallopus* are the smallest —the first about four feet long, and the last "about the size of a fowl," and probably light enough to hop about. The larger forms, such as *Iguanodon* in Europe, and *Claosaurus* and others in America, reached about thirty feet in length and fifteen in erect height. These animals, (like Crocodiles) adapted for both swimming and walking, have left their tracks on former mud-flats and sand-banks, as in Sussex and Connecticut. In the latter district they are mingled with possible bird-tracks and probable labyrinthodont footprints.

Beginning with the Trias, they ended their career in the early part of the Cretaceous period; and they brought with them certain structural peculiarities, which became more developed and specialized in Birds. The *Pterodactyle* (flying reptile) and *Archæopteryx* (reptilian bird) present other such evidences of progressive stages among life-forms.

The "Ancient Birds" have Chap. viii. to themselves, bringing the reader through the Cretaceous period, with its toothed birds, to a few centuries and less ago when the Moa, Dodo, Solitaire, and Great Auk have succumbed to destructive Man.

Chapter ix. begins a new era of the history of the "Creatures of Other Days," with animals of the Tapir and Elephant types; those belonging to the Horse, Whale, and Wombat occupy Chapters x. and xi.; and some extinct South-American creatures, and the Californian Ox, end the series in Chapter xii.

The most advanced and highest Mammals are doubtlessly shown in Plates i. and xii., though the latter is placed in the Dinosaur chapter; for Richard Owen, Huxley, Marsh, Cope, von Zittel, and Gaudry, are here pourtrayed as representative palæontologists. The other numerous illustrations have also been carefully prepared, and in many cases are artistically good.

Certainly verbal errors (by author or printer) are not absent; and there are obscurely elliptical phrases, such as "the genus must have been as large as an ostricht" (p. 161). The author's own "kind friends" will probably have drawn his attention to some such weaknesses, and to points on which differences of opinion are held. We need only say that the book is clearly and pleasantly written; it is full of desirable information well considered and conveniently arranged.

T. R. J.

CORRESPONDENCE.

DYNAMICAL METAMORPHISM.

SIR,—In connection with my friend Mr. Harker's remarks on experimental dynamic metamorphism, some of your readers may be interested to try for themselves one of the simplest cases. Apparatus—a teaspoon, a lamp, a sheet of paper, and a few crystals

of Biniodide of Mercury. Heat the scarlet crystals in the teaspoon over the lamp; they become pale yellow. Place them on the paper, and rub them with the thumb-nail, and they become scarlet again. They are now reduced to a red powder colouring the paper. Pass the paper to and fro over the lamp, the scarlet instantly turns yellow. Attempt to rub the powder off by passing the paper over the carpet, the paper instantly turns red again.

Miller explains the change from yellow to red as follows:—"Warrington has shown that this change of colour depends upon a change in the molecular constitution of the salt, in consequence of which the rhomboidal crystals are converted into octahedra with a square base." This alone would be sufficiently perplexing, but the changes seem capable of being produced over and over again, and we have simply to alternate thermal and dynamic metamorphic processes to produce the yellow biniodide and the scarlet biniodide of mercury at pleasure. If these things may be done in the drawing-room, what may not thermal and dynamic metamorphism, alone or combined, effect in the laboratory of nature?

One more possible case. In using the soldering iron (which iron is always copper) a very moderate temperature is essential to keep the solder on the face of the clean copper, a temperature far below that requisite to melt copper with tin to produce one of the copper-tin alloys; yet occasionally the soldering iron will show streaks of yellow gun-metal. An amateur in his attempts at soldering is apt to press the soldering iron heavily on his work, and it seems possible that the alloy indicated on the iron may arise from insufficient heat being reinforced by equally insufficient pressure; the two combined being, however, sufficient to produce an alloy of copper and tin. If this be so we have in the soldering iron a case of thermal and dynamic metamorphism in combination, just as in the biniodide of mercury we have thermal and dynamic metamorphism in alternation.

A friend employed on the Manchester Ship Canal once sent me a specimen of red sandstone from a slickenside. At the plane of contact and pressure the red colour is entirely discharged, and the stone apparently porcellanized. The depth to which the metamorphic action extends is so very slight, sometimes less than $\frac{1}{8}$th of an inch, that the metamorphosis would seem due to pressure rather than heat, as it is difficult to understand how pure thermal action could be restricted to such a mere film.

Torquay, 16*th June*, 1894. A. R. Hunt.

SHELLS FROM PORTLAND RUBBLE DRIFT.

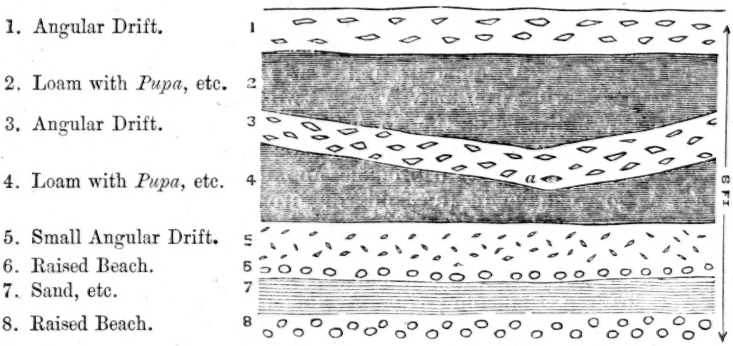
Sir,—I had the pleasure of several hours work in June last at the Rubble Drift at Portland, both at Chesilton and at the Bill.

I was not able to obtain any recent shells from the Chesilton Rubble; but I would remark on the enormous angular and sub-angular blocks of Portland oolite that occur in this section at various horizons, the whole of the material being unsorted, and therefore having been accumulated by more or less rapid aggregation of material in a comparatively brief space of time.

At Portland Bill, in the loam or loess between strata of angular *débris* from the Middle Purbecks, I found an interesting collection of land and fresh-water shells. Mr. Edgar A. Smith, of the British Museum (Natural History), has kindly determined the species for me. They are:—

Succinea oblonga (Drap.)	41 specimens.	*Pupa muscorum* (Linn.)	56 specimens.
Limnæa peregra (Linn.)	4 ,,	*Cyclostoma elegans* ...	1 ,,
Helix hispida (Linn.) ...	1 ,,	*Pisidium*, sp.	1 ,,
Helix pulchella	5 ,,		

These shells are entire, but very brittle. A great many broke to pieces in the process of washing out, and reduced my spoils. The *Cyclostoma* was dug out of a large block of fallen loam by my wife, but in such a position as left no doubt of its genuineness. Fifteen of the *P. muscorum* are immature specimens; two of them have only two whorls. Professor Prestwich has hitherto only found the operculum of *Cyclostoma* at the Battery, Folkstone, and *H. hispida* and *H. pulchella* at the same place. *Pisidium* does not occur in his lists of Rubble Drift Shells as given in the Raised Beach paper (Quart. Journ. Geol. Soc. 1892, vol. xlviii.), and of the above list only *S. oblonga*, *L. peregra*, and *P. muscorum* are named from Portland Bill. I also found four specimens of *Littorina litorea* in the Rubble



Section of the Rubble-Drift, Portland.

Drift, one at a height of 4½ feet above the raised beach, from which they have probably been derived. A large piece of mammalian bone also occurred at the bottom of the second seam of angular Rubble Drift, at (*a*), and which is only slightly adherent to the tongue. I give a rough sketch of the section.

Shoreham Vicarage, Kent. R. Ashington Bullen.

Geological Survey of India.—We are glad to announce that Major C. L. Griesbach, C.I.E., F.G.S., has been appointed (July 17th) Director of the Geological Survey of India, after about twenty years service, *vice* Dr. Wm. King, F.G.S., retired.

Errata:

Geol. Mag. August Number, pp. 337 and 339, for *Nanopus* read *Nasopus*.—O. C. Marsh.

Ibid. p. 364, line 19 from bottom, for *Trias* read Permian.—A. Irving.